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BUILDING AND OPERATING THE LOGISTICS COMPOSITE MODEL (LCOM) FOR NEW WEAPON SYSTEMS
Part A


Eugene R. Richards, Jr., 1st Lt, USAF
Engineering Specialties Division
Directorate of Equipment Engineering


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DEPUTY FOR ENGINEERING
AERONAUTICAL SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

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This technical report has been reviewed and is approved for publication.

EUGENE R. RICHARDS, JR., 1st Lt, USAF
Project Engineer

FOR THE COMMANDER

PAUL D. SMITH, Lt Col, USAF
Director, Equipment Engineering

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The purpose of this documentation is to update AFHRL-TR-74-9[illegible] (II), Simulating Maintenance Manning for Weapon Systems: Building and Operating a Simulation Model, Volume II by incorporating modeling techniques that reflect the Logistics Composite Model (LCOM) Software Revision 4.1, 1 January 1981. This report provides a detailed description of the Aeronautical Systems Division (ASD) procedures for using the LCOM. It is intended to serve as a manual of instructions and procedures needed to build and operate an LCOM data base.
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Block 20. (Continued)

The main thrust of this report is in the use of LCOM for the acquisition of new weapon systems; however, these techniques may be used for other purposes.

# PREFACE

This report is an updated version of Simulating Maintenance Manning for Weapon Systems: Building and Operating a Simulation Model, Volume II, (AFHRL) TR-74-97 (II) and supersedes that manual. This report has been divided into two sections, A and B.

Part A replaces Chapters I through V in AFHRL TR-74-97 (II). These chapters are: Chapter I, Introduction; Chapter II, Defining an Operations Schedule; Chapter III, Main Aircraft Servicing Networks; Chapter IV, Corrective Maintenance Networks; and Chapter V, Networks for Phased and Periodic Scheduled Maintenance.

Part B replaces Chapters VI through IX and concerns the actual running of the simulation and the use of LCOM in determining manpower requirements. Part B will be expanded to incorporate typical ASD sensitivities and will include system readiness information needed for Secretary of the Air Force Program Reviews (SPRs).

This report incorporates changes and additions made to the basic LCOM simulation software, and accurately represents Revision 4.1 dated 1 January 1981.

This report provides a detailed description of the ASD procedures for using the Logistics Composite Model (LCOM). It is intended to serve as a manual of instructions and procedures needed to build and operate an LCOM data base. The main thrust of this report is in the use of LCOM for the acquisition of new weapon systems, although these techniques can be adapted for other model uses. These procedures were originally developed by a joint research and development team at the Aeronautical Systems Division, Air Force Human Resources Laboratory (AFSC), Wright-Patterson AFB, OH.

The initial report was authored by Donald C. Tetmeyer, Major (now Colonel) USAF and William D. Moody, SMSgt (now GS-13), USAF in December 1974. A debt of gratitude is owed to these gentlemen and all those individuals who assisted them in their work.

For this report, the following individuals provided significant contributions to this completed manuscript: Mr Richard Cronk, William Radcliffe, Captain, USAF and Mr Charles H. Begin. Without their assistance, this report would not have been possible.

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SECTION I

INTRODUCTION

A. WHY ASD USES LCOM

The environment of increasingly complex weapon systems and equally complex support systems has created a requirement for improved scientific tools to assist in the evaluation of these systems. A technique was needed that permitted a systematic approach to analysis of the support requirements for complete weapon systems. Computer simulation was selected as the best means of analyzing support systems on an item-by-item basis in terms of their effect on operating performance. Although the initial interest was in logistics support areas, simulation further permitted an across-the-board analysis of other types of support resources, i.e., men, test equipment, etc.

Logistics Composite Model (LCOM) software employs simulation to analyze the impact of all types of support resource shortages on the operational status of a weapon system. The LCOM software together with the data representing a weapon systems environment form study models that permit the analysis of the weapon systems support requirements.

The Aeronautical Systems Division (ASD) currently uses the LCOM for two Department of Defense (DOD) directed requirements. The first requirement is to develop manpower requirements; the second, to verify the supportability and maintainability of major weapon systems.

DODI 5000.2 and AFR 800-15 provide the justification for the manpower use of LCOM in systems acquisition.

> ....manpower and personnel factors, to include numbers, occupations, and skill levels of manpower required, shall be included as considerations and constraints in system design. (29)

> ....Insure that tradeoffs (trade studies) to reduce manpower requirements are conducted within the context of the planned operational and support concepts and with full consideration of life cycle costs. Insure that the potential manpower impact of proposed changes to design, logistics support, or employment are adequately assessed. (17:3)

In September 1980, HQ AFSC proposed that System Readiness information be included in the Secretary of the Air Force Program Reviews (SPRs). (See Attachment 1). The LCOM will be used to show the ability of aircraft weapon systems to sustain wartime operations and provide input for a "Systems Readiness-Sustainability" chart.

ENESA is the focal point for ASDs use of LCOM. The LCOM software is maintained by the Air Force Maintenance, Supply, and Munitions Management Engineering Team (AFMSMMET), Wright-Patterson AFB, OH.

## B. GENERAL FLOW PROCESS OF LCOM AT ASD

Figure 1 shows the major elements in the modeling of new weapon systems. The maintenance tasks required on the new aircraft are estimated using Air Force experience with similar subsystems in existing aircraft plus a factor which may be applied for differences in design. This experience data is obtained from Maintenance Data Collection System (MDC) data processed through the Common Data Extraction Programs (CDEP). (4) Block 1 in Figure 1 represents use of the CDEP to obtain comparable data from a number of current aircraft, Block 2 shows the operations and maintenance scenario that must be constructed for the new aircraft. Using command inputs are needed at this point. When processed through a series of translation programs, these data are the input to Block 3, the LCOM simulation.

The simulation model determines the manning for the given scenario. Other directed analysis, such as trade-off studies, would require different simulations. In Block 4, results from simulation runs are used to compute regression curves for manpower and other directed analyses.

The LCOM scenario contains all assumptions, operating policies and flying schedules. Therefore, the LCOM results are different for each scenario. For example, a typical wartime model would require shorter task times, no shop support, and deferrable maintenance when compared to a peacetime model. Different analysis requirements may also dictate different levels of model complexity and methodologies used.

## C. HOW THE SIMULATION WORKS

The necessary inputs to the LCOM include: Daily mission schedules (defining when aircraft are to fly and for how long), main aircraft servicing networks (defining the tasks, times, and resources to prepare and launch an aircraft at its scheduled time and service it on return), corrective maintenance networks (defining the tasks, times, and resources to fix each subsystem when it breaks), failure rates (defining how frequently each subsystem is likely to require corrective maintenance), and the quantities of each resource (aircraft by type, men by AFSC and shift, LRU spares and support equipment (AGE)).

Figure 2 shows a simplified diagram of how the simulation uses these inputs to simulate a sequence of maintenance activities that would take place in an operational unit flying a specified schedule. Initially, resource levels are entered into the simulation to provide a pool from which resources are subsequently drawn.

When the schedule calls for an aircraft to start preparation for a mission, the simulation checks the number of aircraft in available status (those not flying or in maintenance) and assigns (or reconfigures) those needed for the mission. Each of the assigned aircraft then begins processing through the appropriate main aircraft servicing network, using the resources needed for the time specified in the task data. The simulation keeps records on each resource. For example, when all load teams are already working on tasks of equal or higher priority, the loading task on another aircraft will be delayed (or placed on backorder status) until a load team becomes available.

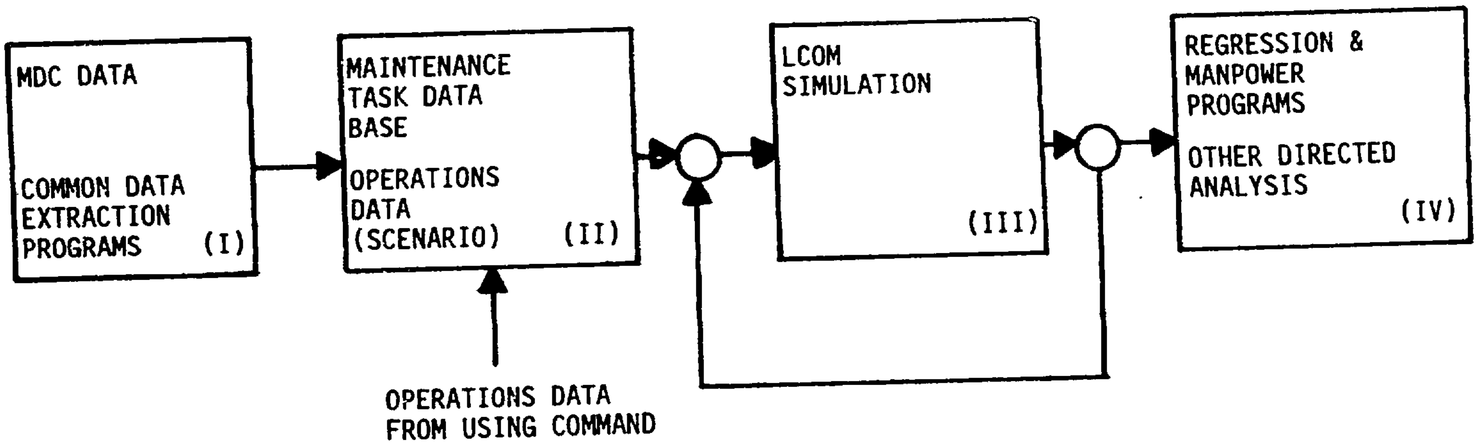



Figure 1. Model Development and Operation.

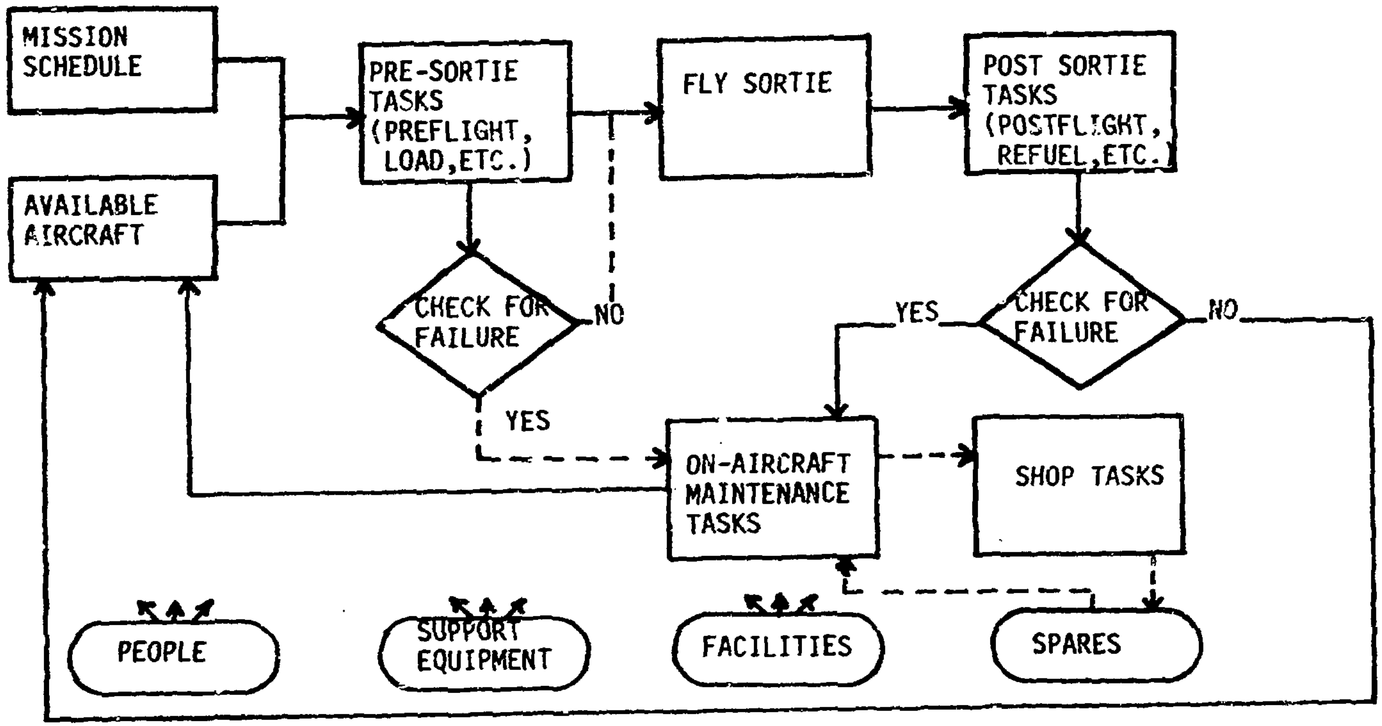



Figure 2. How the Simulation Works.

At scheduled takeoff time, if enough aircraft are ready to go, the planes are launched and "fly" for the specified mission duration. At the end of this time, they return to base and process through the post sortie servicing and maintenance tasks.

The simulation maintains a failure clock for each subsystem. (A failure clock is a counter telling how often a failure occurs.) A random draw is made from a subsystem failure distribution to determine the number of sorties until the next corrective maintenance action on that subsystem will be required. Whenever an aircraft processes pre- or post-sortie, each subsystem is checked for failure. If any failures occur, the simulation lists it as a required corrective maintenance action on that aircraft. The tasks in the corrective maintenance network for that subsystem must be completed before the aircraft can be returned to available status.

The lower the initial resource levels (the more constrained), the more tasks are delayed; aircraft take longer to return to available status, and fewer missions are completed. The extent of the mission loss depends on the timing of the mission schedule and resultant backordering of resource demands.

## D. RELATIONSHIP OF THE INPUT FORMATS

The hierarchic relationships among input data are shown in Figure 3. An operations schedule is contained on LCOM Forms 20 (AF Form 2720). Forms 21, 22 and 23 (AF Form 2721, 2722, and 2723, respectively) define the decision rules to use in picking the appropriate aircraft. LCOM Form 17 (AF Form 2717) identifies the appropriate main aircraft servicing network for each mission type. These networks are initially coded and entered into the data base on Extended 11 Forms (AF Form 2719). These Extended 11 Forms are converted later to LCOM Forms 10, 11, 12, 13 and 14. (AF Form 2710, 2711, 2712, 2713, and 2714, respectively) (NOTE: Do not confuse the Extended 11 Forms with LCOM Form 11; they are not the same.) Networks define the sequencing of tasks to be accomplished and the time and resources required for each task. The main networks also contain appropriate clock decrements and call tasks. Decrement tasks specify when and on what basis clocks are to be decreased, and the call tasks specify when these clocks are to be checked and any required maintenance accomplished. The corrective maintenance networks and the failure distributions for each subsystem are entered into the data base on Extended 11 Forms as well. (The Extended 11 Form will be discussed in greater detail in a later chapter.)

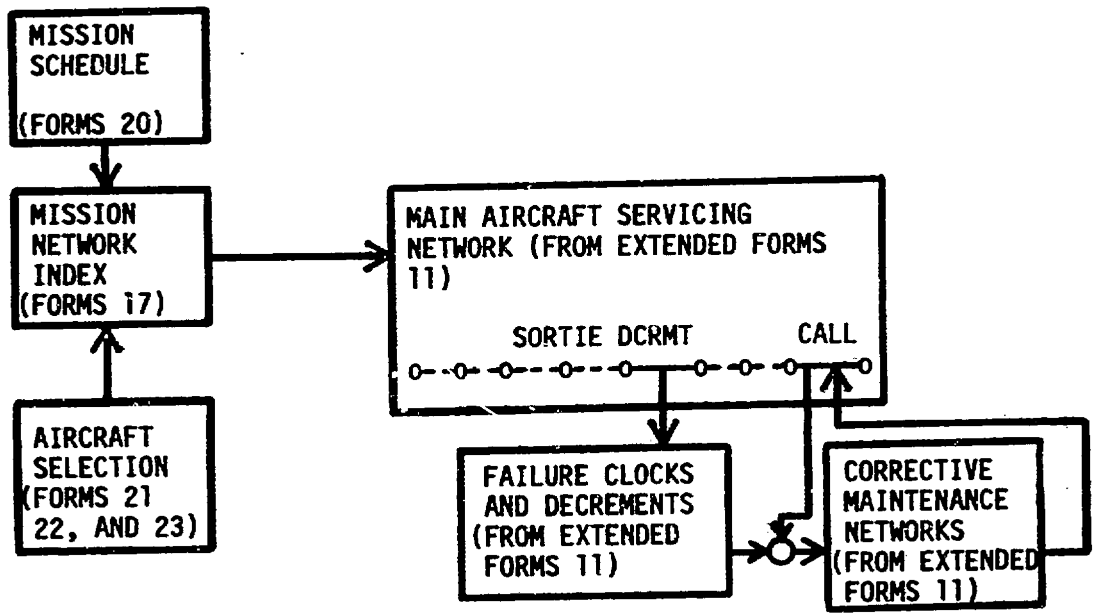



Figure 3. Relationship of Inputs.

## SECTION II

## DEFINING AN OPERATIONS SCHEDULE

### A. COORDINATING THE ASSUMPTIONS

Often, the most difficult step in building an operations scenario is getting agreement on the specific mission requirements. These requirements must be coordinated and agreed to among the decision makers and organizations who are going to use the end results. Few combat aircraft have only a single mission and single possible modes of operation in all situations. Operations scenarios can range from a low sustaining rate of peacetime training flying by a full wing at an established CONUS (Continental United States) base, to a round-the-clock combat surge by a single squadron deployed at a forward base. Scenarios must be defined that are appropriate to the decisions and plans that will be made with the model results. For example, the CONUS wing training scenario cannot be used to determine manning for a deployed squadron in combat.

The requirements office in the operating command is a primary source of information on operations plans for new aircraft.

The following information should be included in a scenario for use in LCOM. Items listed are to be used as a checklist and should be added to or deleted as appropriate for the particular aircraft and situation being modeled, and included in the final report.

a. General Requirements:

(1) Organization level and unit equippage (UE: also referred to as PAA, Program Authorized Aircraft) by aircraft type.

(2) Manpower availability (manhours per month).

(3) Percentage of available manhours which must be allowed for indirect work.

(4) Standard manning for Chief of Maintenance overhead and for any workcenters which will not be simulated.

(5) Acceptable, Not Mission Capable Supply (MNCS) rate.

b. Facilities and Deployment:

(1) Number of locations and UE (PAA) sizes at each location.

(2) Resupply time.

(3) Allocation of equipment, such as support equipment (AGE) at each location.

(4) Extent of maintenance capability required at each location.

(5) Shelters and facilities at each location.

c. Mission Requirements: Identify mission types. Specify the following mission requirements for each mission type; or each leg of each mission involving enroute sorties.

(1) Percent of total sorties.

(2) Aircraft type.

(3) Initial configuration (e.g., numbers and types of external tanks, ECM pods, cameras, guns, missiles, bombs, cargo handling and passenger comfort equipment, etc.).

(4) Probability of, and quantity of, load expended (e.g., tank jettision, air-to-air missile firing, etc.) by mission type.

(5) Ending configuration and disposition.

(6) Substitution rules for using alternate configurations.

(7) Mission Priority.

(8) Flight sizes (maximum, minimum) and policy of sympathetic ground abort and spares.

(9) Mean sortie length and variation.

(10) Recovery or enroute point (if not returning to same base).

(11) Probability and conditions of air refuel.

(12) Proportion flown at night.

(13) Weather limitations by mission type (e.g., for bomb delivery, air refuel, air engagement, etc.).

(14) Length of delays that can be tolerated before mission cancellation (e.g., for weather, maintenance, etc.).

(15) Extent of operation of mission peculiar equipment (e.g., photographic equipment, if mission calls for reconnaissance.)

(16) What missions will have sympathetic ground and/or aborts?

d. Operations and Scheduling Policy:

(1) Base and target weather minimums for launch and recovery.

(2) Conditions for air abort (including sympathetic).

(3) Policy for ground and/or airborne spare aircraft.

(4) Desired percent of available aircraft which will be turned to fly again the same day, if possible.

(5) Requirements for massed launch within a restricted time frame.

(6) Requirements for complimentary missions and mission legs within a restricted time frame.

(7) Definition of day missions (e.g., between 0600 and 1800 hours).

e. Ground Alert:

(1) Number of aircraft on alert per UE (PAA).

(2) Which mission flown from alert, as identified in paragraph c above.

(3) Frequency of alert missions.

(4) Replacement policy (e.g., replacement when launched, or same aircraft return to alert.)

(5) Duration of alert cycle.

(6) Disposition at end of alert cycle.

(7) Aircraft acceptance and/or alert quick turn policy and procedures.

(8) Policy for dedicating personnel and equipment to alert.

f. Functional Check Flights (FCF):

(1) Conditions requiring FCF.

(2) Limitations on FCF (e.g., daylight only).

(3) FCF duration and probable range of variation.

g. Maintenance Concepts and Organizations:

(1) Organizational structure (e.g., per AFR 66-1).

(2) AFSC structure (e.g., integrated avionics versus functional avionics specialists).

(3) Quick turn conditions and procedures, including extent of deferred maintenance.

(4) Remote versus home station maintenance, including criteria for deferred maintenance.

(5) Policy for launch support.

(6) Conditions requiring download of munitions.

h. Combat Damage:

(1) Identify the probability of attrition and battle damage.

(2) Probability of an aircraft returning from battle damage requiring a Rapid Aircraft Maintenance (RAM) team and/or reserve augmentation.

(3) Policy for allocating combat damage repair to base, RAM team and depot.

i. Crew Ratio Study Assumptions:

(1) Identify by mission type:

(a) The time before scheduled takeoff that briefing should begin.

(b) The time after landing when debriefing will be completed.

(c) Any reduction in briefing/debriefing time when missions are flown in succession.

(2) Describe aircrew scheduling rules:

(a) Formed crews.

(b) Multiple seat qualifications.

(c) Flight lead or special qualifications.

(d) Squadron Integrity.

(e) Additional duty requirements (if applicable, identify additional duties and hours required per shift.

(f) Maximum flight duty period.

(g) Minimum crew rest periods.

(h) Days off policy.

(i) Probability of aircrew recovery after being shot down.

(j) Maximum number of missions per flight duty period.

(k) Overhead posture.

(3) If applicable, identify specific excursion requirements. (AFR 25-8 establishes procedures for obtaining an approved LCOM scenario.)

SECTION III

# MISSION/SORTIE ANALYSIS

## A. GENERAL

The LCOM provides great flexibility in establishing missions, sorties, and activities that an aircraft can perform. It also provides limited capability for defining external and internal configuration for each aircraft. This allows the modeler to specify different classes and different internal configurations of aircraft for different missions.

The modeler follows a hierarchy in classifying an aircraft. This is depicted by Figure 4. The "aircraft type" is stipulated on the Form 20 and reflects the weapon system modeled. This is the first level of the hierarchy.

The second level concerns the aircraft class. It is depicted on the Form 17 and normally corresponds to the types of missions required, i.e., close-air-support (CAS), interdiction (INTD), combat-air-patrol (CAP), etc. This level and the next are where external configurations are primarily used.

The next level is the status of the aircraft. An aircraft can be maintained by external configuration in one of three states: (1) available, (2) cocked, and (3) in use. An aircraft is considered available if it is ready for assignment, but requires the processing of pre-sortie tasks before a sortie can be accomplished. A cocked aircraft is one that could fly immediately on some missions, that is, it's fully configured and requires no processing of pre-sortie tasks. It begins the mission at the sortie task. However, a cocked aircraft assigned to a mission that requires the aircraft to be reconfigured will become an available aircraft and will process pre-sortie tasks. An in-use aircraft is processing some piece of network or is on the sortie task. Available and cocked aircraft are both capable of being assigned to mission requirements. In-use aircraft are not available for assignment.

The last level of Figure 4 represents the internal configuration of aircraft. Each aircraft is capable of having a unique set of internal equipment. These unique sets are described by internal equipment groups.

The forms that the modeler has at his disposal for mission/sortie definition are the AF Form 2717 (Form 17), Mission Entry Points; the AF Form 2720 (Form 20), Sortie Generators; the AF Form 2721 (Form 21), Aircraft Assignment Search Patterns; the AF Form 2722 (Form 22), Internal Equipment Authorizations/Changes; and the AF Form 2723 (Form 23), Internal Equipment Group Definitions. Forms 22 and 23 are only required if internal configuration is desired. Forms 17, 21, and 20 are necessary for each simulation.

## B. CONFIGURATION MANAGEMENT

Configuration management allows the users of LCOM to maintain significant external control of aircraft usage. This control considers the aircraft's configuration which can be in terms of either external or internal configuration, or both.

External configuration is normally descriptive of the ordinance loading of an aircraft, or anything externally mounted that could change the aircraft's

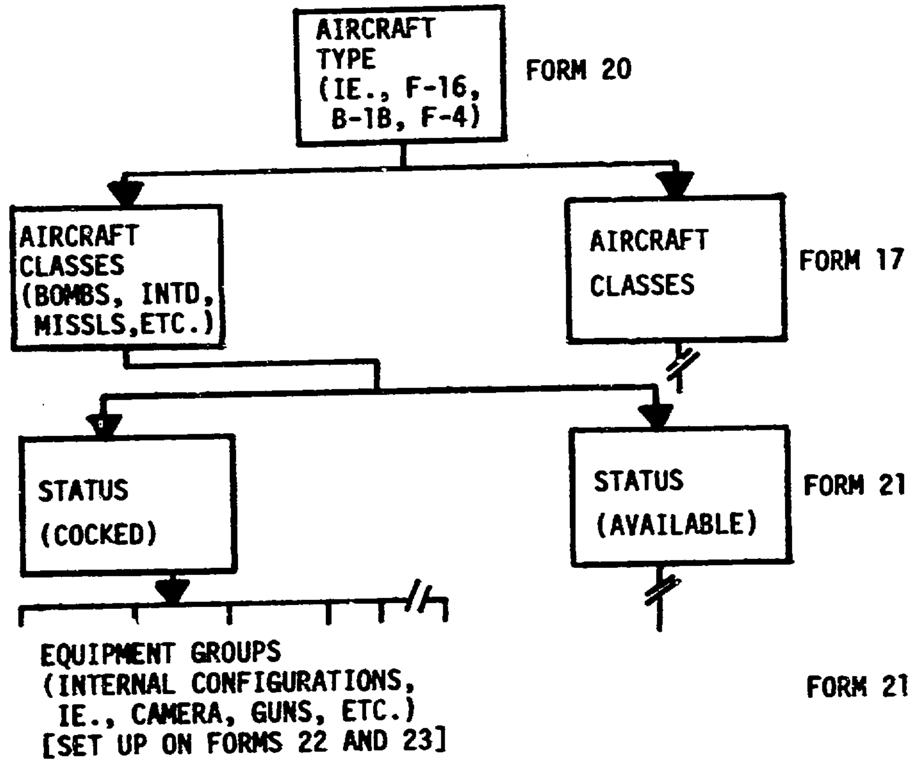



Figure 4. Aircraft Classification Hierarchy.

use characteristics; for example, bombs, missiles, racks, etc. Internal configuration refers to a specific piece, or set of, internal equipment, whose condition (availability on the aircraft) can also change the aircraft's use characteristics; for example, a gun, or a camera. It is used as a method to track and model deferred maintenance.

The modeler can control aircraft usage by configuration, changes of configuration through reconfiguration, and selection based upon estimated times to prepare the aircraft for missions.

The first step in configuration management is an in-depth analysis of all possible external and internal configurations. Once defined, an attempt to consolidate them into as few different configurations as possible must be made. The ground rules for this consolidation process should include, but not be limited to, consideration of the following five questions:

(1) What types of answers or results am I looking for and what impact will the different configurations have on these results? Areas of prime consideration include tasks with significantly different times or crew sizes, operational substitutability, etc.

(2) How many of the possible configurations are actually used and to what extent? It may be that 25 different configurations are possible, but only six (6) or seven (7) constitute 95% of all the missions flown.

(3) During the process of configuration changes (reconfigurations), are there special requirements for checkout of the configurations, i.e., special tasks or resources required?

(4) In terms of internal configurations, are there any special networks to be developed and what impact might they have on aircraft availability?

(5) What impact will reconfigurations have on aircraft pre-sortie time?

## 1. EXTERNAL CONFIGURATION

As previously stated, aircraft are maintained by external configuration in one of three states: (1) available, (2) cocked, and (3) in use. When an aircraft completes its flight and all its maintenance (reaches the end of (main) network), an attempt is made to immediately reassign it to any mission. If it is not needed, it is placed in the post-sortie external configuration. Cocked aircraft are aircraft that completed pre-sortie processing for a mission (as prime or spare), but did not fly. For example, if an aircraft is in pre-sortie unscheduled maintenance and the mission cancels, the aircraft will complete processing to the sortie task. They carry the pre-sortie external configuration class (defined on Form 17) of the mission they missed.

When a mission or activity from the Form 20 file is requested, the Form 17 is referred to. The Form 17 specifies which aircraft assignment search pattern the simulation should follow. The Form 21 defines these search patterns, the sequential order of aircraft configurations acceptable for the mission, and how these aircraft configurations are to be reconfigured to meet the mission requirement. External configuration can be used to represent weapons load and other mission-related configurations. Each aircraft, by tail number, is identified by a particular configuration. All aircraft are, at the start of simulation, configured as the first configuration specified on the Form 17 or as the configuration specified on a "STORAC" change card. Dummy activities can be used at simulation time zero to establish the proper proportion of aircraft per external configuration.

Each search pattern listed on the Form 21 has an ordered list of configurations to examine. Each aircraft is examined and compared to this list of configurations. If a match is found, the aircraft is entered into the reconfiguration entry mode for that configuration. This entry mode defines the network of tasks needed to prepare the aircraft for the mission.

The cut-off time specified for each searched configuration allows more efficient selection of aircraft. If the remaining time to mission cancellation is less than the specified cut-off time for a listed configuration, that configuration is skipped and the search is continued. If the minimum aircraft listed on Form 20 have already been assigned and are ready to fly, the cut-off time test uses the scheduled takeoff time instead of cancel time. If the cut-off times are properly based on task times for reconfiguration and pre-sortie processing, this feature will prevent aircraft from being prepared for missions they cannot make. Space is provided for two (2) configuration choices on each line of the Form 21. Continuation cards ("C" in Column 11) can be used for additional configuration choices for the same mission name. The order of search for a given mission name is first line left entry, first line right entry, second (continuation) line left entry, second line right entry, third (continuation) line left entry, etc.

If a Form 21 calls for a cocked aircraft and blank reconfiguration modes, the aircraft will go directly to the sortie task, bypassing through all pre-sortie processing in zero time. This can be unrealistic in some situations where pre-sortie launch networks should be processed by cocked aircraft. To correct this it is suggested that external configuration networks be used to identify loading tasks and preflight tasks. Pre-sortie networks should only include launch tasks (walkaround, engine start, etc.). Whenever aircraft process any reconfiguration network (this could be simply a dummy task), they will process the pre-sortie network. This is because cocked aircraft are converted to available aircraft whenever a reconfiguration network is entered. The user must take care to assure that all possible configurations that could occur in the course of the simulation have some disposition on Form 21. This can be accomplished by running the flying schedule preprocessor program.

2. INTERNAL CONFIGURATION

Each aircraft can be identified as having a unique group of internal equipment items (such as gun, camera, radio, TACAN, etc.) functioning. This is known as internal configuration and is defined and specified on Forms 21, 22, and 23. (AF Forms 2721, 2722, and 2723, respectively).

Form 21 lists the equipment group name of equipment items needed for the particular mission. This equipment group, which is defined on Form 23, specifies a unique combination of internal equipment. It lists the equipment name as well as the minimum quantity required for a mission. For example, if an aircraft has two (2) cameras operational and the equipment group on Form 23 specifies two (2), one (1), or zero (0) cameras, the aircraft will satisfy that equipment group. The user should be extremely careful to insure all possible combinations of equipment are considered on Form 23. For this reason, the number of internal equipment items to be considered for internal configuration should be kept to a minimum.

Once an aircraft is found that satisfies the internal equipment group listed on the Form 21, the simulation will have the aircraft enter the internal recoginition entry node, if one is listed, on the Form 21. This network will take the necessary actions to change the aircraft internal equipment to meet mission needs.

Form 22 gives the network nodes which change equipment authorizations. As soon as an aircraft enters this node, the equipment is decremented or incremented by one (1) unit. These trigger nodes must have a "T" selection mode coded on the Form 11. No other tasks should be placed in parallel with these "T" selection mode tasks. The "T" selection mode has the same characteristics as the "D" selection mode. "T" nodes that subtract are usually placed following the failure clocks in lieu of the repair networks. "T" nodes which add are placed in front of the repair networks with the entry node specified on the Form 21. Form 22 also sets the authorized quantity. Each aircraft is initialized to this authorized quantity at the start of simulation.

### 3. RECONFIGURATION SUMMARY

Reconfiguration is that action which takes an aircraft of one configuration and converts it to another configuration. Special networks are defined by the user for this purpose. In the case of external configurations, those networks might contain tasks which download one type of ordinance and upload another or the upload of ordinance on a clean aircraft. In the case of internal configurations, those networks might contain tasks that repair a type of internal equipment. The user must be careful to insure that the desired internal configuration is actually obtained, remembering that the equipment groups specify the minimum equipment. All other combinations with higher equipment levels will satisfy lower equipment level requirements.

Generally, the first configuration in the search pattern specified by a mission is the one requiring the least effort to reconfigure. Normally, the most acceptable search procedure would be to search for a cocked, then an available, aircraft of the required configuration. However, this is entirely under user control through the definition of search patterns on the Form 21.

## C. CONFIGURATION MANAGEMENT EXAMPLE

To further illustrate the previous sections, the following configuration management example will be used. Figure 5 through 8 are the required networks and Figures 9 through 13 are the applicable Form 20, 17, 21, 23, and 22.

The weapon system modeled is called the "FX-16". It is an experimental fighter that will have two mission types, MISSLS, for missiles, and RECON, for reconnaissance. The internal equipment will consist of a camera and gun. A MISSLS mission requires an airplane configured with one camera and one gun. A RECON mission requires an airplane configured with at least one camera. Figure 12 shows the possible combinations of internal equipment that will occur.

At the beginning of the simulation, all aircraft are configured externally as MISSLS and internally as GROUP1 (1 camera, 1 gun). The activity PRECON, as shown in Figure 9, will occur at time zero to externally configure half of the 48 aircraft to RECON (internal configuration is unchanged). Half of the aircraft will be scheduled to fly MISSLS missions at 0100 each day for the duration of the simulation (in this example a 30-day period is assumed). The remainder will be scheduled to fly RECON missions at 0200. Since both type missions are similar, we will only discuss the networking for a MISSLS mission.

The simulation begins with a requirement for an aircraft to fly a MISSLS sortie at 0100. The mission request, which comes from the Forms 20, actually asks for an aircraft at scheduled takeoff time (0100) minus lead time (.20). This is known as the FRAG TIME and represents the actual simulation time the mission request is known to the simulation. In this case, FRAG TIME is at 0048.

The simulation begins looking for an aircraft to fill the mission request by checking the search pattern specified on the Form 17 (Figure 10), in this case, "SP1". SP1 is defined on the Form 21. The first configuration specified is an available MISSLS with GROUP1 internal configuration.

If an aircraft with this external and internal configuration is found, it will enter the network through the entry node specified on the Form 17 (Figure 10); in this example MN0001. The aircraft enters the network shown in Figure 5, pre-sortie tasks are performed, the aircraft flies the mission, and after completing this sortie task, checks for any failures in the unscheduled maintenance networks. Unscheduled maintenance failures are fixed and the aircraft completes post-sortie tasks and is released for another mission.

When the aircraft is released for other missions, it is in one of two possible configurations. The first possible configuration is externally configured as CLEAN1 and internally configured as GROUP1. This only occurs if no unscheduled maintenance has been done. If unscheduled maintenance has occurred then the aircraft is configured as CLEAN1 and GROUP3.

The change of internal configuration from GROUP1 to GROUP3 is caused by the call to unload camera and gun. This happens after unscheduled maintenance. Figure 5 shows these networks. The tasks SUBGUN and SUBCAM are defined with the trigger selection (T) mode. This means the prior node of these tasks are defined (on Form 22, Figure 13) to subtract a value of one (1) from the aircraft configuration list, thus making it a GROUP3.

The next aircraft the simulation searches for, if an "available" MISSLS, GROUP1 is not present, is a "cocked" MISSLS, GROUP1. This aircraft goes through a "DUMMY" node (See Figure 8) with a blank task name. This changes the aircraft from a "cocked" to an "available" before beginning main network processing. This causes the aircraft to process the pre-sortie tasks. If it had remained a "cocked" aircraft, it would have started processing at the sortie task.

If another MISSLS sortie is requested an no "available" or "cocked" MISSLS are in the ready pool, the next aircraft requested will be an available CLEAN1, GROUP1. The mission requires MISSLS external configuration, therefore the CLEAN1 must be reconfigured to meet this mission requirement. This reconfiguration is done by entering the Form 21 (Figure 11) reconfiguration entry node, in this case node REC003.

When the aircraft enters REC003 (See Figure 8), a task is accomplished to load missiles. After completing this task, the aircraft is externally configured as a MISSLS and processing begins at node MN0001 of the main network (See Figure 5).

If an available CLEAN1, GROUP1 cannot be found, the simulation searches for an available CLEAN1, GROUP3. This aircraft must be reconfigured externally and internally. The internal configuration occurs first. The aircraft enters the internal reconfiguration node listed on the Form 21 (Figure 11), REC001 (See Figure 7). The tasks ADDGUN and ADDCAM are defined as trigger (T) nodes on the Form 22 (Figure 13). After the aircraft completes these tasks, it will be internally reconfigured as GROUP1. The aircraft then completes the same external reconfiguration as explained for CLEAN2, GROUP1. At this point, the aircraft has been changed into a MISSLS/GROUP1 configuration.

For example, aircraft returning from MISSLS or RECON sorties become externally configured as CLEAN1 or CLEAN2. These are the post-sortie configurations listed on the Form 17 (Figure 10). If for some reason the sortie cancelled, the aircraft would revert to the pre-sortie configuration listed on Form 17 as "cocked" aircraft. In other words, the pre-sortie configuration defines the cocked configuration the aircraft will go into when missions cancel.

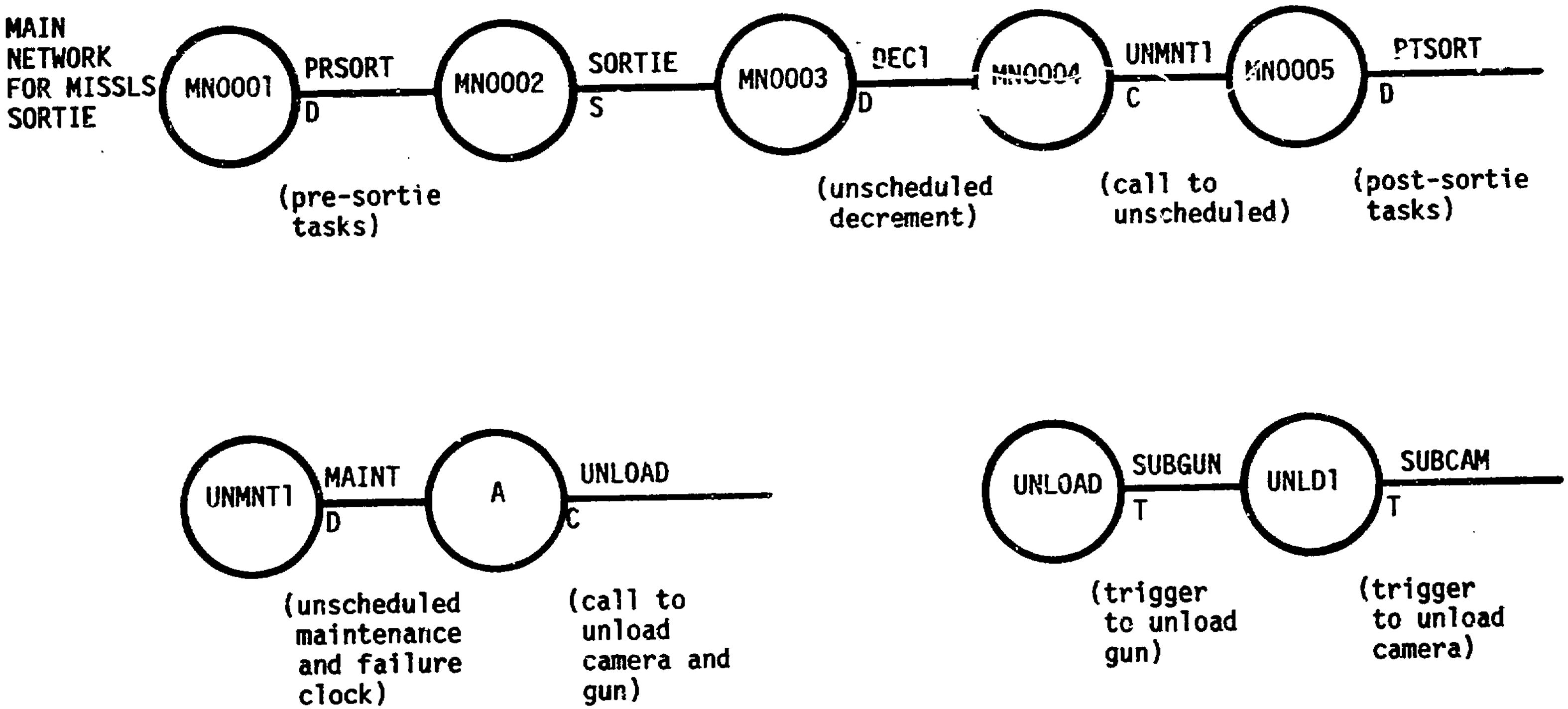



Figure 5. Configuration Management Example - Main Network for MISSLS Sortie and Network to remove Internal Equipment.

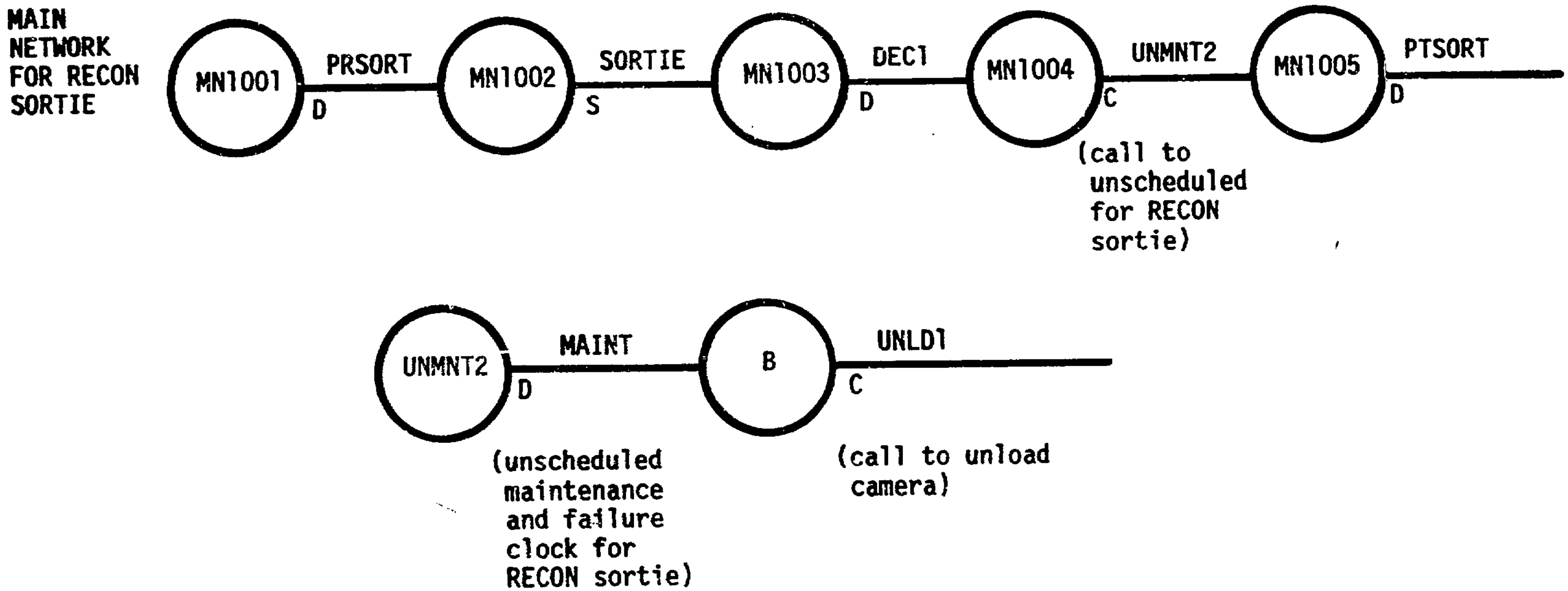



Figure 6. Configuration Management Example - Main Network for RECON Sortie.

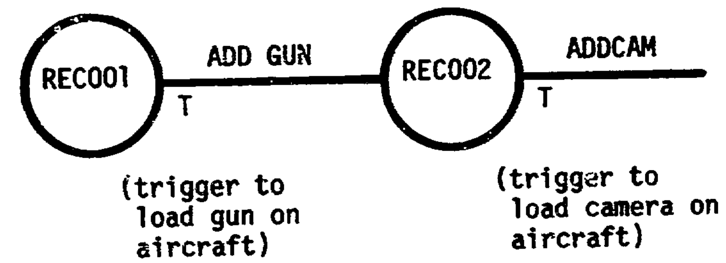



Figure 7. Configuration Management Example - Internal Reconfiguration Network.

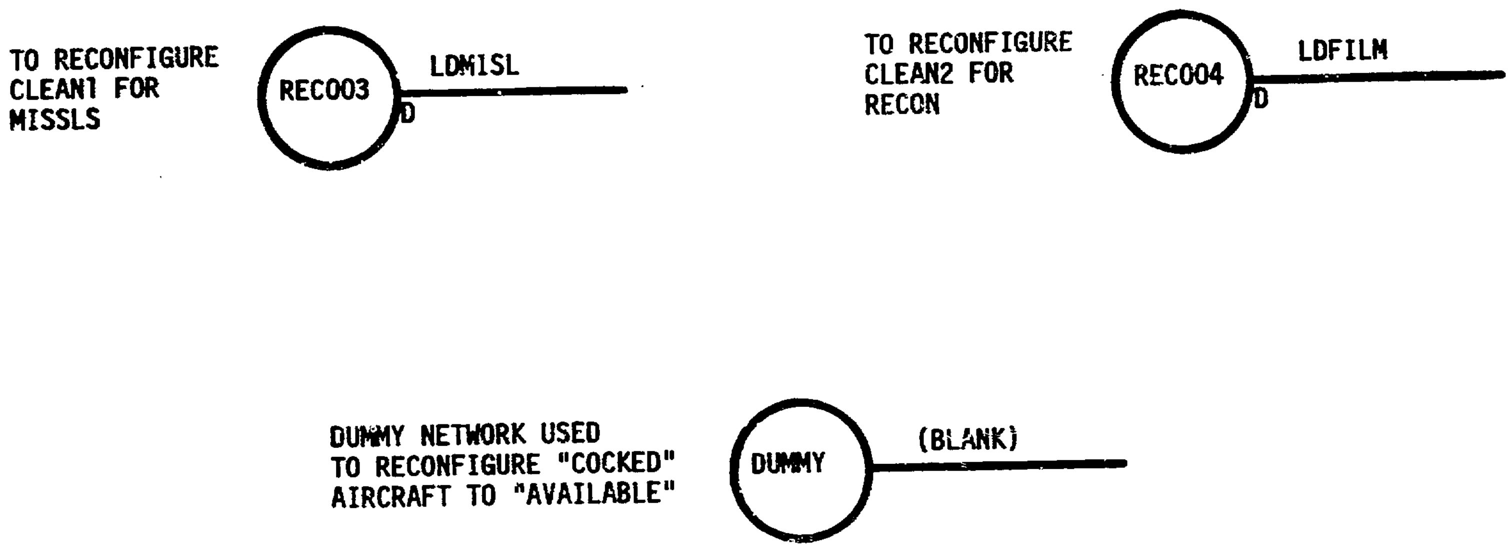



Figure 8. Configuration Management Example - External Reconfiguration Networks.

LOGISTICS COMPOSITE MODEL

LCOM II - SIMULATION MODEL INPUT
- SORTIE GENERATION DATA

| CARD I.D. | DAY | NUMBER OF MISSIONS OR ACTIVITIES | TAKEOFF OR ACTIVITY TIME | AIRCRAFT I. D. OR RESOURCE I. D. | MISSION I. D. OR ACTIVITY I. D. | MISSION SIZE MIN | MISSION SIZE MAX | MISSION SIZE SPARE | MISSION LENGTH MEAN (OPTIM) | MISSION LENGTH VARIANCE (LIKELY) | LEAD TIME | CANCEL TIME | PRIORITY | CYCLE INT | CYCLE STOP | TRIANGULAR DISTRIBUTION (PESSIM) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 20 | | | | | | | | | | | | | | | | |
| | 1 | 24 | 0 | FX-16 | PRECON | 1 | 1 | 0 | | | | | | | | |
| | 1 | 24 | 0100 | FX-16 | MISSLS | 1 | 1 | 0 | 1.50 | .50L | .20 | .20 | 1 | 1 | 50 | |
| | 1 | 24 | 0200 | FX-16 | RECON | 1 | 1 | 0 | 1.20 | .20L | .15 | .15 | 1 | 1 | 50 | |
| | 1 | 1 | 0700 | FX-16 | ALERT | 2 | 2 | 0 | 1.00 | .10N | .10 | .20 | 1 | | | |
| | 1 | 2 | 0712 | FX-16 | ALERTA | 1 | 1 | 0 | | | | 12.0 | 1 | | | |



Figure 9. Configuration Management Example - AF Form 2720 (Form 20).

LOGISTICS COMPOSITE MODEL

LCOM II - SIMULATION MODEL INPUT
- MISSION/ACTIVITY ENTRY POINTS

| CARD I.D. | MISSION I. D. OR ACTIVITY I. D. | REPORT COLUMN | NETWORK ENTRY POINT NODE | PRE-SORTIE EXTERNAL CONFIGURATION | POST-SORTIE EXTERNAL CONFIGURATION | AIRCRAFT ASSIGNMENT SEARCH PATTERN | AIRCRAFT NAME |
|---|---|---|---|---|---|---|---|
| 17 | | | | | | | |
| | MISSLS | 1 | MM600/ | MISSLS | CLEAN1 | SP1 | FX-16 |
| | RECON | 2 | MM1001 | RECON | CLEAN2 | SP2 | FX-16 |
| | ALERT | 3 | MM600/ | ALERT | CLEAN1 | SP4 | FX-16 |
| | PRECON | 1 | ANYWAY | MISSLS | RECON | SP3 | FX-16 |
| | ALERTA | 5 | ARECON05 | ALERT | ALERT | SP5 | FX-16 |

Figure 10. Configuration Management Example - AF Form 2717 ( Form 17).

| | | EXTERNAL | | INTERNAL | | | EXTERNAL | | INTERNAL | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CARD I.D. | AIRCRAFT ASSIGNMENT SEARCH PATTERN | CONFIGURATION NAME | RECONFIGURATION ENTRY NODE | EQUIPMENT GROUP | RECONFIGURATION ENTRY NODE | CUT-OFF TIME (HOURS) | CONFIGURATION NAME | RECONFIGURATION ENTRY NODE | EQUIPMENT GROUP | RECONFIGURATION ENTRY NODE | CUT-OFF TIME (HOURS) |
| 2 | | | | | | | | | | | |
| | SP1 | AMISSLS | | GROUP1 | | | CMISSLS | DUMMY | GROUP1 | | |
| | | CACLEAN1 | REC003 | GROUP1 | | | ACLEAN1 | REC003 | GROUP3 | REC001 | |
| | SP2 | ARECON | | GROUP1 | | | ARECON | | GROUP2 | | |
| | | CCRECON | DUMMY | GROUP1 | | | CRECON | DUMMY | GROUP2 | | |
| | | EACLEAN2 | REC004 | GROUP1 | | | ACLEAN2 | REC004 | GROUP2 | | |
| | | EACLEAN2 | REC004 | GROUP4 | REC002 | | ACLEAN2 | REC004 | GROUP3 | REC002 | |
| | SP3 | AMISSLS | | GROUP1 | | | | | | | |
| | SP4 | CALERT | DUMMY | GROUP1 | | | AALERT | | GROUP1 | | |
| | SP5 | ACLEAN1 | | GROUP1 | | | ACLEAN1 | | GROUP3 | REC001 | |
| | | DACLEAN2 | | GROUP3 | REC001 | | ACLEAN2 | | GROUP4 | REC002 | |

LOGISTICS COMPOSITE MODEL — LCOM II - SIMULATION MODEL INPUT - AIRCRAFT ASSIGNMENT SEARCH PATTERNS

Figure 11. Configuration Management Example - AF Form 2721 (Form 21).

| CARD I.D. | INTERNAL EQUIPMENT GROUP | INTERNAL EQUIPMENT NAME | QUANTITY | INTERNAL EQUIPMENT NAME | QUANTITY | INTERNAL EQUIPMENT NAME | QUANTITY | INTERNAL EQUIPMENT NAME | QUANTITY | INTERNAL EQUIPMENT NAME | QUANTITY |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 23 | | | | | | | | | | | |
| | GROUP1 | CAMERA | 1 | GUN | 1 | | | | | | |
| | GROUP2 | CAMERA | 1 | GUN | 0 | | | | | | |
| | GROUP3 | CAMERA | 0 | GUN | 0 | | | | | | |
| | GROUP4 | CAMERA | 0 | GUN | 1 | | | | | | |

LOGISTICS COMPOSITE MODEL — LCOM II - SIMULATION MODEL INPUT - INTERNAL EQUIPMENT GROUP DEFINITIONS

Figure 12. Configuration Management Example - AF Form 2723 (Form 23).

| CARD I.D. | AIRCRAFT NAME | C | TRIGGER NODE | EQUIPMENT NAME | . | AUTHORIZED QUANTITY | TRIGGER NODE | EQUIPMENT NAME | . | AUTHORIZED QUANTITY | TRIGGER NODE | EQUIPMENT NAME | . | AUTHORIZED QUANTITY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22 | | | | | | | | | | | | | | |
| | FX-1H | | REC001 | GUN | + | 1 | REC002 | CAMERA | + | 1 | UNLOAD | GUN | - | 1 |
| | | C | UNL01 | CAMERA | - | 1 | | | | | | | | |

LOGISTICS COMPOSITE MODEL — LCOM II - SIMULATION MODEL INPUT - INTERNAL EQUIPMENT AUTHORIZATIONS/CHANGES

Figure 13. Configuration Management Example - AF Form 2722 (Form 22).

## SECTION IV

## HANDLING ALERTS

Alert missions are sorties randomly scheduled throughout the flying period. These missions are fulfilled by aircraft which have been specifically set aside to meet the unforeseen alert mission. In modeling a TAC-based LCOM, the aircraft are kept in an ALERT POOL or CONFIGURATION, and only these aircraft are searched to fulfill the mission. The alert mission has short lead times (very little notification as in real life) and cancel times. They are usually scheduled in flights of two (2). In other words, the MIN and MAX field is two (2). No spares are scheduled. The priority is one (1). Each time an alert mission occurs, the aircraft which were in the ALERT POOL must be replaced from the fleet of aircraft. This replacement is done using alert replenishment activities. These activities are scheduled shortly after the alert mission, and consist of all the tasks necessary to prepare the airplanes for the ALERT POOL. The same number of alert replenishments are scheduled as alert missions. There should never be more or less, the MXPOOL card is the controlling factor. The replenish activity should have a long cancel time to insure that any delays occurring during the alert mission are covered. When ALERTS are used in the model, the MXPOOL and TACMOD change cards must be used. These change cards prevent more than a specific number of aircraft from being available in the ALERT POOL. At the start of simulation, the proper number of alert replenishment activities must be scheduled at time zero (0) to initially configure the ALERT POOL. All replenishment activities place the aircraft in a "cocked" post activity configuration. This is specified by using a three (3) in column 74 of the FORM 20.

There is a difference in how TAC and SAC schedule their alerts. During the course of the simulation period, those aircraft on alert must be released from alert after so many days. After they are released, they are used to complete a sortie so that the resources used to prepare the aircraft are not wasted. Currently, this must be accomplished by manually scheduling these "first sorties after alert" missions. Efforts are being made to update the CREATE20 software to handle both TAC and SAC alert requirements.

Figure 10 in the previous section shows an alert mission and its applicable replenish activity, ALERTR. For simplicity, an alert mission has been defined as requiring both camera and gun to be loaded, internal equipment GROUP1. This alert is also similar to the MISSLS mission and will perform the same flightline functions. The search pattern for ALERT are shown in Figure 11. Note that the alert mission requires uniquely defined alert aircraft.

## SECTION V

## NETWORKING METHODOLOGY AND TECHNIQUES

### A. GENERAL

A network is a set of tasks listed in the sequence in which they are accomplished. A task is defined as a requirement for resources (men, parts, equipment, facilities) needed for a specific time. Tasks have a sequential or parallel relationship, as defined by the network, to each other. Figure 14 is the basic network terms and definitions. Network data is entered on Extended Forms 11.

In LCOM modeling, networks are divided into two (2) categories. The first, main aircraft servicing networks, apply to the aircraft in general. These networks contain such tasks as towing, preflight inspection, postflight inspections, and servicing LOX/NITRO. Reconfiguration networks, described in the previous chapter, are also considered in this category. The other category of networks are the corrective maintenance networks. These networks consist of the scheduled and unscheduled maintenance actions required to fix subsystems of the aircraft. These categories are arbitrary classifications useful for aircraft data structures. There is no such limitation in LCOM. The user may define data in any manner to suit his needs.

### B. NETWORK ENTRY

During the simulation, task network processing is started by defining an entry point to the network on Form 17 or Form 21. When a mission request is filled, the aircraft (or other resource) filling the mission will process through the tasks of the network. The processing starts at the entry node and ends when there are no further tasks in the sequence. The aircraft can be thought of as flowing through the network, obeying the selection modes at each new branch.

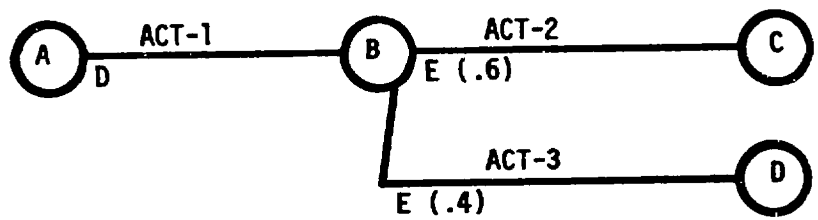
### C. SELECTION MODES

The processing of each task in the network is determined by a selection mode defined in the input data which may specify one of 15 options. These options include modes A, C, D, E, F, G, H, I, J, K, L, R, S, T and U. These modes can be basically subdivided into: those that are discrete functions (C, D and R), those that are probabilistic in nature (A, E and G), those used to control mission timing within the modes (S), and those that deal with specific model features (F, H, I, J, K, L, T and U).

The main module is designed to permit utilization of any of these network selection mode options. They provide the desired flexibility, selection, and control of the scenario chosen by the user. The network feature of the main module provides a means for simulating a large variety of weapon systems and operational environments.

#### 1. DISCRETE FUNCTIONS

Discrete functions are networked using C, D or R modes.




| TERMS | DEFINITION |
|---|---|
| NETWORK | - A Logical flow of actions represented by the above diagram. |
| NODE | - Action connectors such as A, B, C and D above. |
| BRANCH | - Emanating from Node B are two parallel paths or branches. Any number of branches are permitted. |
| TASK | - Action names such as ACT-1, ACT-2, ACT-3, which are accomplished on a particular branch. |
| SELECTION MODE | - The procedure whereby a user defines the network path selection. Examples are the "D" which means DO the task specified, and the "E" which means EITHER DO ACT-2 or ACT-3. |
| SELECTION PARAMETER | - The "E" (.6) means that 60% percent of the time, ACT-2 is done; "E" (.4) means that 40% percent of the time, ACT-3 is done. "A", "E" and "G" selection modes have these parameters. |

Figure 14. Network Terms Definition.

(a) Mode C - Network Section Selection - This "C" or call option permits the user to describe the task network in sections. This eliminates duplicate network data. The call section can be called from any place in the networks. It is analogous to program subroutines. The task name is the entry node to the call section. The simulation will look for this node, enter that section, and then perform the tasks that follow. The entire call section will be completed and then the aircraft will return to the node following the call section and continue processing.

Figure 15 is an example of the "C" selection mode. In the main network shown there are two tasks that use the "C" selection mode; IN1 and IN2. When the aircraft hists the first "CALL" task, it will go to CALL Section 1, Node IN1 and perform the task, HTIRE. After completing that task, the aircraft will return to the main network.

After the aircraft flies its sortie, it reaches another "CALL" section, IN2. The aircraft will go to Node IN2 and perform the task HGEAR. After HGEAR is completed, the aircraft will go to IN1 where it will perform the task HTIRE. After HTIRE is completed the aircraft will return to CALL Section 2, Node D2, and perform the task HDOOR. When task HDOOR is done; CALL Section 2 is completed; the aircraft will return to the main network to continue processing. This example illustrates that CALL sections can be nested within other CALL sections.

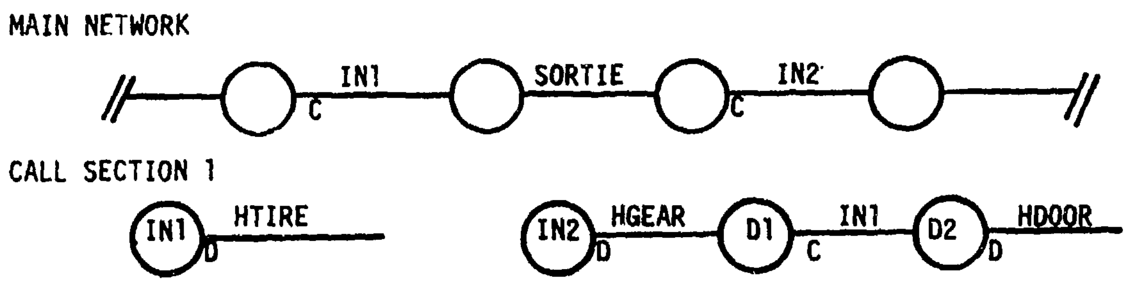



Figure 15. Example of C Selection Mode.

(b) Mode D - "Do the Task" - This option is used when there is no question of selection. When this node is used, it means no criterion is required to select whether or not the task is done. It is always done when it is addressed by a preceding task.

(c) Mode R - Resource Availability Mode - The "R" Selection is a decision mechanism that determines which branch of a network will be processed according to the availability of resources. It checks each "R" coded task from the same prenode in the sequence listed on the Forms 11, and processes the first one that has the necessary resources available. If no task can be processed, it goes back to the first task and waits for its resources to become available. No further search is done. NOTE: The resources checked are only those requested on the applicable "R" task.

The "R" is needed to model avionics repair on new generation test equipment where there are primary/alternate test stations for each LRU. In the example of Figure 16, availability of the primary station T1 is checked first.

A dummy task, CHECK1, is defined with T1 as a resource. If T1 is not free, T2 is checked. If T2 is also in use, the LRU will wait on T1. When T1 is available the CALL section checks for test station failure. If there is no failure, the LRU repair task is accomplished, using T1 as a task resource. If the test station has failed, it is consumed and repaired. The "R" selection mode is then used again to see if T2 is free, and if not, waits for the repair of T1.

Consider another situation where a large aircraft must be brought into a hangar for jacking (See Figure 17). When a hangar is not available it may be jacked outside, provided there is no wind and good weather. The first task would list all the job resources plus the hangar, while the second would be a dummy task listing job resources, but no hangar. When everything was available to do the work except the hangar, the second branch would be selected, allowing the probability of weather to determine whether the job would be done outside or wait on the hangar. A more sophisticated approach would schedule good weather days as a short resource on the Forms 16, and list the good weather resource as a task requirement on the second branch. In that case no "E" probabilities would be required. This kind of modeling gimmickery invites errors and should be restricted to those few instances where it is really essential to the objective of the study.

2. PROBABILISTIC FUNCTIONS

The probabilistic functions are networked using an "A", "E" or "G" mode.

(a) Mode A - Nonmutually Exclusive Probability - This "A" or "Any" selection mode is the option used to select none, one or more of several parallel branches in the network, each of which, involves an independent probability of accomplishment. The selection of each branch is done independently; none, one or more, or all parallel branches might be taken. Since probabilities are independent, they do not have to sum to any particular value. The APROB change card may be used to change the probability of a specific "A" Selection Mode branch at any simulated time.

An "A" Mode should normally be used in parallel with either a "D" or an "E" Selection Mode. If an "A" Mode is used by itself, or in parallel with another "A" Mode, there is a possibility that the aircraft will not do that task and stop processing at that point.

Figure 18 shows an example of an "A" Selection in parallel with a "D" Selection. The end-of-runway check will always be done. Ten percent (10%) of the time, however, the ECM pod will be removed as well.

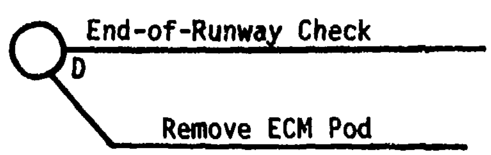



Figure 18. A Selection Mode.

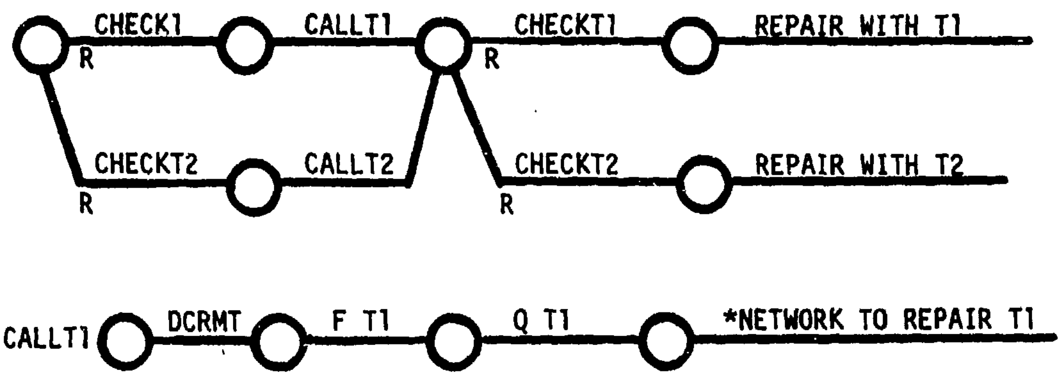



Figure 16. R Selection Mode - Example #1.

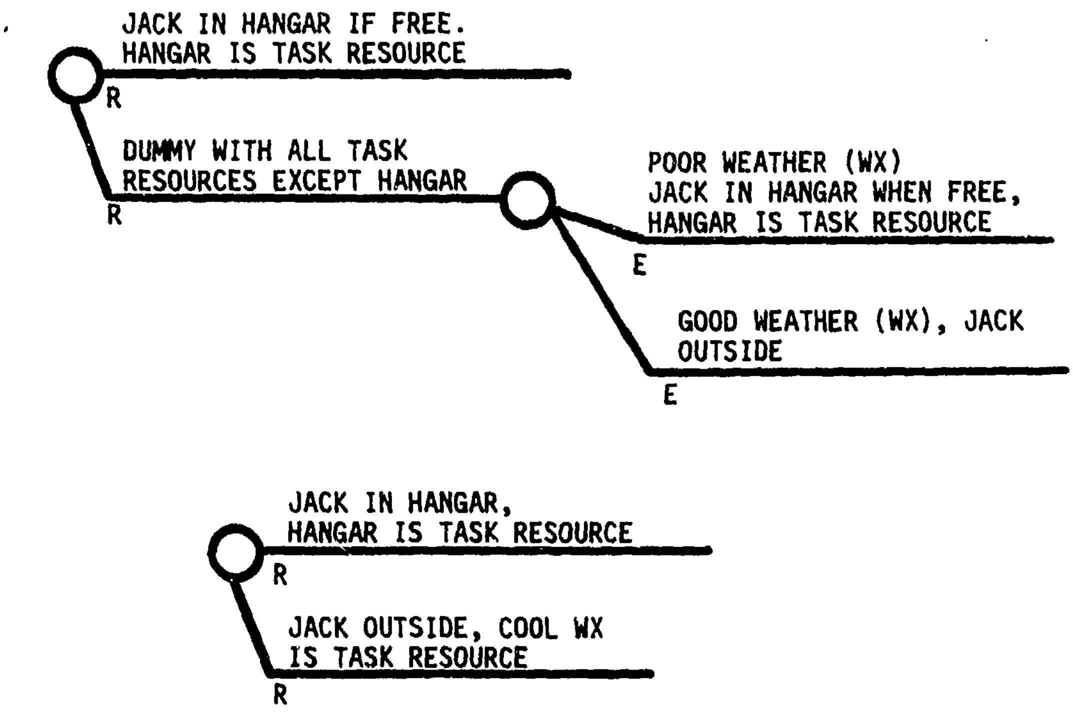



Figure 17. R Selection Mode - Example #2.

(b) Mode E - Mutually Exclusive Probability - This "E" or "Either" Selection Mode is the option used to select only one of several possible parallel tasks in the network. Since the probability values are mutually exclusive, all possibilities should be accounted for and the sum of the probability values from the same node must sum to 1.0. A Restriction when using this mode is to not mix two sets of "E" branches emanating from the same node. The EPROB change card may be used to change the probability of a specific "E" Selection Node branch at any point in time during the simulation.

Figure 19 shows an example of an "E" Selection network. From the entry node, a choice of one task or the other will be made. Seventy-five (75%) percent of the time, a "Remove-and-Replace" action will be done. The other twenty-five (25%) percent of the time, a task called "Minor Maintenance" will be done.

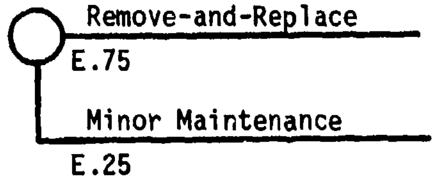



Figure 19. E Selection Mode.

(c) G Mode - Nonmutually Exclusive Probability The "G" or "Get" at least one, selection mode is the same as the "A" Mode with a slight modification. Remember that when processing a parallel set of "A"'s, the rule is that any, all or possibly none, of the branches may be taken, depending on the individual random numbers drawn. The "G" Selection differs in two (2) respects. First, if these same "A" tasks were instead marked "G" and none were selected, then the model would recycle (take another set of random draws) until at least one "G" task was chosen. Secondly, the "G" Selection Mode is statistically different than "A" when considering the independence of failures. The probability of no selection is zero (0). Use of the "G" Mode will increase simulation run time (computer time), particularly if small "G" Selection parameters are used. The only restriction on use of the "G" Mode is that if it is used at a particular juncture/node, then all tasks emanating from that juncture/node must also be "G" Selection Modes. The GPROB change card may be used to change the probability branch at any point in time during the simulation. (3: Appendix H)

Figure 20 shows an example of a "G" Selection Network. At the entry node the simulation will make a draw. If no task is chosen, draws will continue to be made until at least one task is selected.

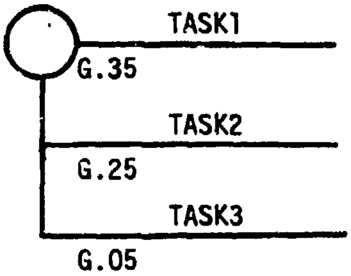



Figure 20. G Selection Mode.

3. CONTROL MISSION TIMING

Mission timing control is networked using the "S" Mode.

Mode S - Sortie Task Timing Control - This "S", or "Sortie", option is assigned to the sortie task, a task whose starting time and duration is controlled by the mission data (AF Form 2720 (Form 20)). When this option is encountered on a task, mission data is used to establish the task time (sortie length). There should only be <u>one</u> sortie task (S Mode) in a main network.

The "S" Mode task can decrement failure clocks by flying hours. Be careful when decrementing clocks by sortie length. If you have more than one main network leading to a sortie, you must check for clock failures within each network. Failure clocks are not decremented until they have been referenced within the network. In other words, no failure will take place unless the failure clock has been checked before end-of-network.

4. SPECIFIC MODEL FEATURES

Specific model features can be networked using "F", "H", "I", "J", "K", "L", "T" and "U" Modes.

(a) F Mode - Failure Mode Selection - This "F" or "Failure" option means task accomplishment will be controlled by a failure clock within the network. The Failure Clock mechanism represents subsystem malfunctions that occur on aircraft. Within the simulation, it indicates when tasks following the clock are to be done.

Figure 21 is an example of how the "F" Selection Mode may be used. CALLS1 is the naming convention of the node that the unscheduled maintenance networks are tied into. The numbers after the "F" Node are the values of the failure clocks. When these clocks are decremented to zero (0), the clock indicates a failure, and when it is checked, the task following this clock will process. A discussion of the failure mechanism follows:

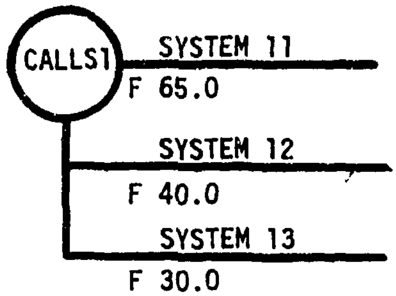



Figure 21. F Selection Mode.

The methodology for inducing resource failure into the simulation is designed to provide the greatest possible flexibility in use of this failure mechanism. The basic mechanism can be thought of as a clock that is utilized to trigger action within the network. This clock is first set to some value, a random variate or constant, then successively decremented by defined amounts when processing certain network tasks, until the value is zero (0). Upon reaching zero (0) a failure of some sort has occurred; information is stored concerning where in the network this clock was referenced; the clock is reset in a manner similar to the original setting; and later successively decremented for the next failure. Clocks can represent, and be driven by, almost an failure criteria such as; number of aircraft, sortie time, resource operating time, absolute time, etc.; limited only by the users' ingenuity.

Each clock is defined on the Extended Form 11, in terms of its mean, variance, and distribution type. Decrements for each clock must also be provided on the Extended Form 11. The model uses these parameters to initially set and reset the clocks. With the exception of the triangular distribution, all standard and empirical distributions can be used.

Clocks are used within the networks by specifying an "F" Selection Mode and using the clock as the parameter. The user can use a clock with an "F" selection parameter in more than one place in the network. When a clock reaches zero (0), information about all the locations in the network concerned with the clock are used to control the network processing. This information is provided to the resource whose network processing caused the clock or clocks to breach (fail).

To decrement the clocks, the task name used to decrement must be specified on the Form 14. The Form 14 lists all the clocks in the model, the decrement mode, and the value of the decrement. Any desired combination of failure setting and decrementing can be included in a simulation, such as listing the same failure clock under two different decrement tasks and values. However, tasks can only be identified once on the Form 14 and can only decrement by one mode.

Another application of the "F" Selection Mode is to control network processing (F task stringing). "F" task stringing is defined as: Sequential tasks in the network being controlled by the same clock.

To further understand the use of this method of controlling network processing, let us consider the requirement of unloading an aircraft's munitions and then parking it in a shelter to perform unscheduled or phase (scheduled) maintenance. This is especially important when a surge condition is modeled with a "Quickturn" methodology. (The aircraft flies a sortie, and is immediately, unless broken, processed for another sortie.)

In Figure 22, a "CALL" is made to an unscheduled maintenance check. The aircraft will enter into the network entry node, CALUM. The simulation will skip over the UNLOAD and SHELTR task and then check the unscheduled (tied to node CALLS1) and phase (tied to node CALPHAS) failure clocks. (The "X" in the selection mode is used on the Extended Form 11 to indicate "F" task stringing.) If a clock has breached (failed), the aircraft will go back and process the UNLOAD and SHELTR tasks, otherwise, it will return to the main network and be released to the aircraft pool in its post-sortie configuration.

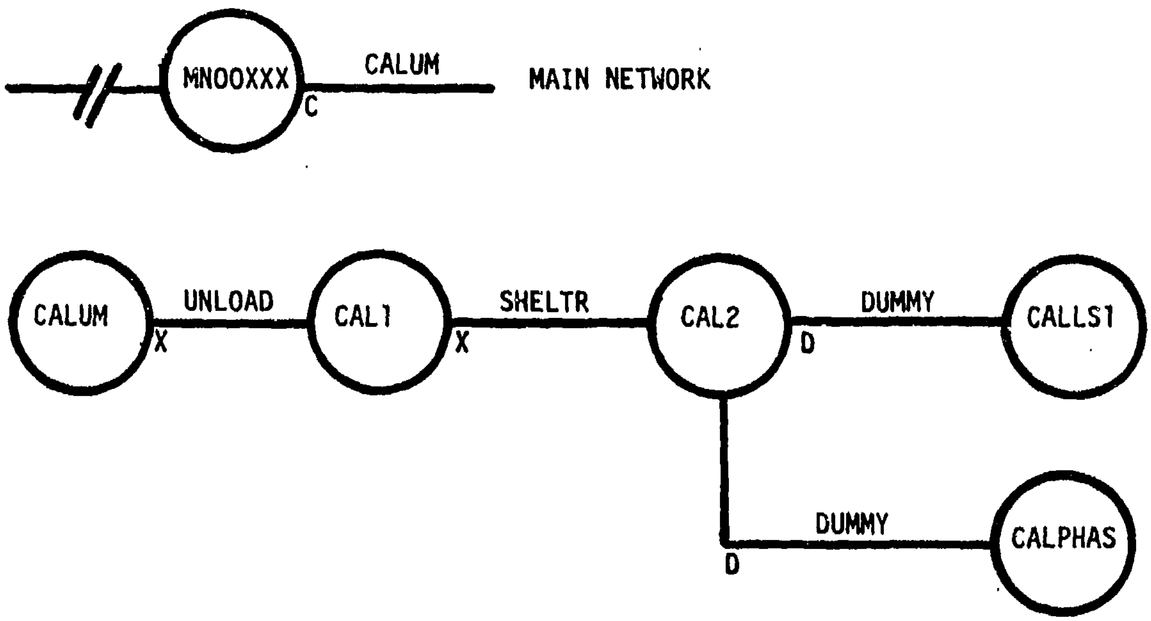


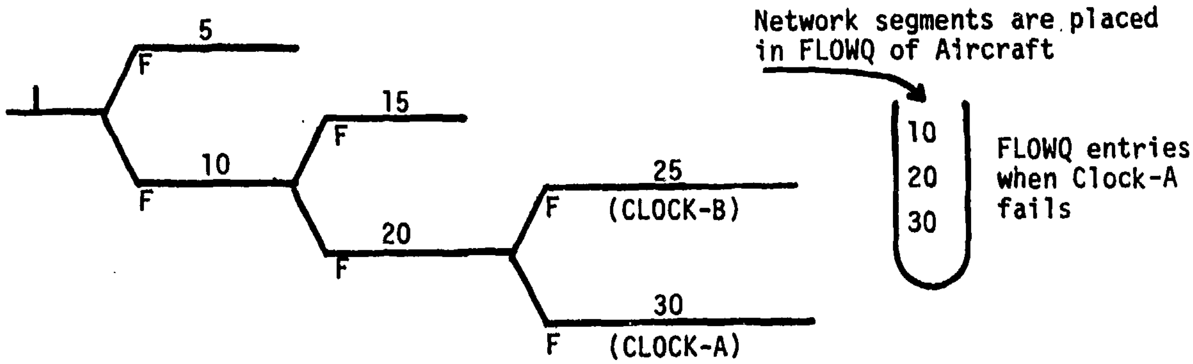

Figure 22. F Task Stringing.

Figure 23 is a listing of four other examples of "F" task stringing. It gives the "do's" and "don't's" of "F" task stringing. Another application of failure clocks is multiple locations controlled by the same clock.

Figure 24 illustrates the use of this feature. Suppose an aircraft normally used an on-board APU (Auxiliary Power Unit) for starting, but could be started with an MA-1A (ground starting unit) if the APU failed. A pre-sortie call section would include the decrement and an "F" task for the APU clock, followed by tasks to get an MA-1A and start the engines. The post-sortie unscheduled maintenance call section should include an identicial "F" task followed by tasks to fix the APU. Whenever the APU decrement failed the clock at aircraft starting, both "F" tasks would be triggered. LCOM would allow the aircraft to be started by the MA-1A, but APU repair would be deferred until picked up after the flight. Each clock name should only be used for one "F" task in the LCOM data base unless this feature is specifically desired.

EXAMPLE 1

In this example, the FLOWQ contains data to control network processing triggered by a failure of CLOCKA. Segments 10 and 20 are controlled indirectly by this clock as they are coded F selection mode and lead directly to network segment 30. Set FLOWQ contains a 30, 20, and 10. If CLOCKB had failed and the FLOWQ would contain 25, 20, and 10. If both had failed the FLOWQ would have contained 30, 25, 20, and 10 (no duplicates).




EXAMPLE 2

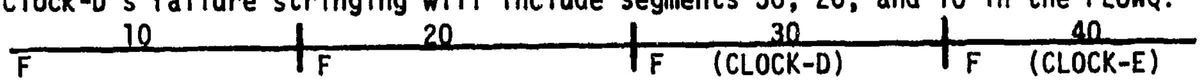
F stringing will not happen between network section. In this example, these two Fs will not string when Clock-C fails. FLOWQ only contains a 20.


EXAMPLE 3

F stringing will be accomplished thru all proceeding F tasks, even those with valid parameters.

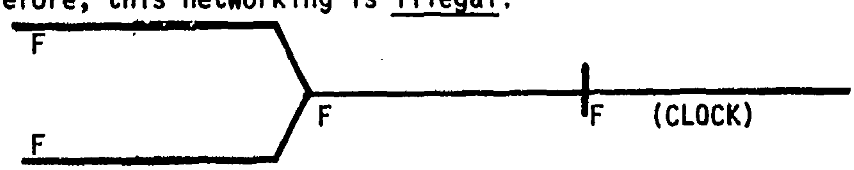
Clock-E's failure stringing will include segments 40, 30, 20, and 10 in the FLOWQ.

Clock-D's failure stringing will include segments 30, 20, and 10 in the FLOWQ.




EXAMPLE 4

Two F segments in parallel cannot lead to a single F segment controlled or uncontrolled because the model has no way of knowing which way to string back. Therefore, this networking is <u>illegal</u>.




NOTE: All numbers in the above networks represent network segment locations, not task numbers.

Figure 23. F Clock Stringing.

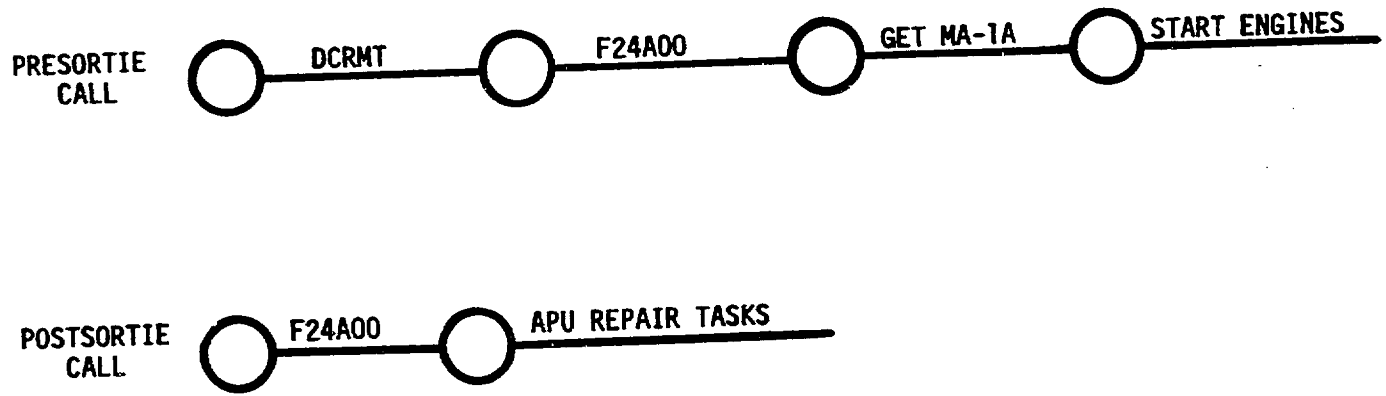



Figure 24. F Selection Mode - Multiple Failure Clocks.

(b) H Mode - Halt Mechanism Controlled - The "H" or "HALT" Mode acts like the "F" Mode except in the reverse. If a HALT clock has breached for a particular "H" task, the processing of that particular task and the subsequent network tasks will HALT at that point.

The HALT clock is a network gate that operates as a mirror image of a failure clock. It normally remains open and allows tasks to process through it. When a "failure" occurs, it closes the gate and eliminates the requirement to process the following tasks. The HALT clock is then reset into an open position until the next failure occurs. Forms 14 are used to specify decrements for HALT clocks in the same way as for failure clocks. (NOTE: The phase program generates a decrement of 1.0 for HALT clocks on the Form 14s.) The task name on the HALT clock should be different from any failure clock.

Consider the "H" as a failure generated stopping point in a particular leg of the network being processed. As implied here, the "H" Selection is handled by the user just like the "F" with one exception; "H" tasks must be independent of each other; that is every "H" Selection Mode must have an "H" clock associated with it. This ensures that "H" tasks will not be strung together like "F" tasks. (No stringing of "Hs" with "Fs" or other "Hs" is permitted.)

HALT clocks are useful for modeling "if" conditions. As in Figure 25, suppose a C-130 aircraft is to divert to a Remotely Piloted Vehicle (RPV) recovery site when at least two (2) recovered RPVs are ready for pickup, but proceeds directly back to home base otherwise. Resource RPVR represents a recovered RPV at the recovery site. A HALT switch can be set up with parallel decrements and HALT clocks. One branch tries to consume two RPVs (Note that this must be within a call section to prevent the subsequent network from being processed twice.). The second branch has a time delay followed by a decrement. If the consumes are not done within this time, a HALT clock is triggered on the first branch to stop further processing. The aircraft proceeds directly back to home base on branch two (2). It also generates two (2) RPVs to clear the consume task on branch one (1), and returns the stock of RPVs waiting airlift back to the original level.

If the two (2) RPVs were immediately available, the aircraft would process along the first branch and trigger a HALT on branch two (2). The tasks would involve landing, loading, launch, fly, land, unload, generate resources to represent RPVs at home station, and post-sortie maintenance and service on the aircraft and RPVs at home.

(c) I Mode - Cannibalization Data Mode - The "I" or "Ignore", Selection Mode is used in conjunction with the cannibalization mechanism. It is used only on tasks that consume a part and indicate to the cannibalization mechanism that the part being consumed should be included in the list of cannibalized parts. It also tells the normal processing to ignore the task time when the part is received from supply.

The purpose of the cannibalization feature is to obtain aircraft for a mission at FRAG time through a cannibalization action, when the on-hand balance of the aircraft is less than the minimum required. Several items work together to control the use of this feature.

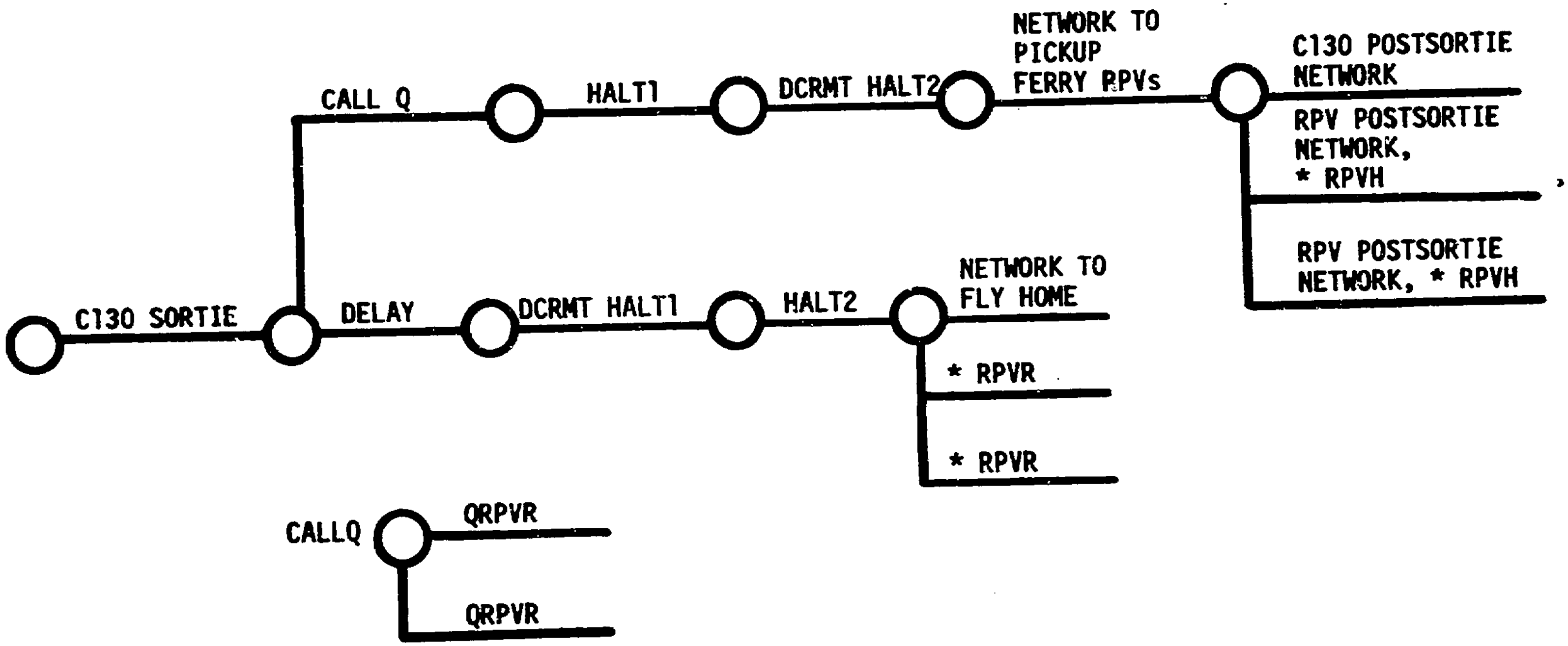



Figure 25. H Selection Mode.

The CANSWT change card is used to enable the feature (CANSWT =1, ON) or disable it (CANSWT =0, OFF). The user must set the CANSWT "ON" or cannibalization will not take place. (Default for CANSWT is zero (0).)

Cannibalization cannot take place unless the "I" Selection Mode task is used. The "I" Mode specifies those tasks containing part consumptions that can take advantage of cannibalization.

The "I" Mode also indicates that the time specified is a cannibalization removal time. During normal processing where the part is obtained from supply (on-hand quantity is greater than zero (0)) the time is to be ignored. However, if the part is unavailable from supply, the task would be backordered and the aircraft would probably be NMCS (Not Mission Capable Supply). If the demand for this part is to be satisfied by another cannibalization action, the time and manpower resources specified on the "I" Mode task would be used.

When activated, cannibalization reviews all in-use aircraft to qualify them as candidate donors or candidate acceptors. Only NMCS aircraft can be considered as either donors or acceptors. Given that the donors and acceptors are qualified, the Main Module then determines if the manpower resources on the "I" Mode task are available. If so, and donors and acceptors are matched up, the Main Module: (1) simulates the removal of the part from the donor, (2) dedicates the part to the acceptor, (3) delays the processing of the acceptor part demand task until the part is available, and (4) establishes a like demand for the part on the donor aircraft ( a copy of the acceptor network from the "I" Mode task to the end of the network is filed against the donor aircraft.).

Other external controls are available to the user. The maximum number of part demands for acceptor aircraft that can be satisfied by cannibalization has a default of two (2). Also the maximum number of holes on (parts obtained from) a donor aircraft that can be made through cannibalization has a default of five (5). The CANNIB change card allows the user to change these quantities, by aircraft type.

The user may, in this network, control where he wants a part consumption task considered for cannibalization action by use of the "I" Selection Mode as previously described. Use of the "D" Select Mode where you never want cannibalization to occur.

There can be only one of a particular part cannibalized at a time for a particular aircraft. If more than one demand for a part is backorder, all demands except the last must be satisfied before cannibalization may be used.

Figure 26 is a summary of the rules for cannibalization.

(d) T Mode - Trigger Node Controlled - This "T", or "Trigger", Selection Mode is used for the configuration management of internal equipment on an aircraft. It is treated as a DO task for network processing purposes, but will trigger either the loss or gain of some internal piece of equipment. (NOTE: When dealing with parallel branches, only one (1) "T" can be used and it must occur first in the Form 11s.) Please refer to Section III, the "Internal Configuration" sub section, for a more detailed explanation of this selection mode.

THE RULES GENERATING THE USE OF CANNIBALIZATION

1. CANSWT (Simulation Change Card) must be set to one (1).

2. "I" selection mode must be used on tasks with a part consumption to be considered for cannibalization.

3. Only a single part consumption and men resources are permitted on an "I" mode task.

4. If the "I" mode is used, the task time is always ignored except during cannibalization.

5. If the "I" mode is used on a task without a consume on it, the Input module assumes the mode is "D" (DO), makes the substitution, gives a message, and continues.

6. The CANNIB change card can reset the maximum number of parts to cannibalize for, and the maximum number of "holes" permitted on an aircraft (DONOR) caused through cannibalization.

7. Acceptor Aircraft - Aircraft which satisy the following conditions are set up as candidate acceptor aircraft.

   a. No scheduled or unscheduled jobs are in process.

   b. At least one part is backordered.

   c. Only parts are backordered.

   d. Aircraft in post sortie or activity processing.

   e. Tasks backordered and eligible for receiving a cannibalized part must be only jobs backordered for the aircraft.

   f. The number of tasks backordered and eligible for receiving a cannibalized part must be liss than or equal to a limit determined by the user.

   g. The aircraft cannot be waiting for dedicated parts from a previous cannibalization action (be a current acceptor).

   h. The aircraft cannot have an in-process donation to another aircraft (be a current donor).

Figure 26. Rules for Cannibalization - I Selection Mode.

1

THE RULES GENERATING THE USE OF CANNIBALIZATION (Continued)

8. Donor Aircraft - Aircraft which satisfy the following conditions are set up as candidate donor aircraft:

a. No scheduled or unscheduled jobs are in process.

b. At least one part backordered.

c. Only parts are backordered.

d. Number of jobs backordered plus in-process removals must be less than the maximum number of holes (limit) permitted on the aircraft.

e. Cannot be waiting for dedicated parts from a previous cannibalization action (be a current acceptor).

f. Must be post-sortie or activity processing or an aircraft pre-sortie processing whose mission has flown or cancelled.

FIGURE 26. Rules for Cannibalization - I Selection Mode (concluded)

2

(e) J, K and U Modes - Aircraft Timing Switches - The "J", or "Jump", Selection Mode is used to partially activate the "Aircraft Timing Switch".

The "K" or "Kill", Selection Mode is used to fully activate the "Aircraft Timing Switch".

The "U", or "Unschedule and Unset" Mode is used to deactivate the "Aircraft Timing Switch" after it has been fully turned on and a reset for it has been scheduled.

The Aircraft "K" Selection Mode timing switch, KTIMSW, controls the processing (or not processing) of network tasks coded with a "J" or "K" Selection Mode.

The primary control of the setting and resetting of this switch is done by tasks coded with a "K" Selection Mode. A Secondary Control for resetting the switch is done by tasks coded with a "U" Selection Mode. The switch is a three (3) position switch (off = 0, partially on =1, fully on = 2).

When the switch is off, or partially on, both "J" and "K" Selection Mode tasks are processed. When fully on, these tasks are skipped. The partially on condition permits users to process series of "J" Mode tasks, even with intervening tasks using other selection modes. These "J" tasks will set the switch to partially on.

"K" tasks, however, will set the switch fully on, regardless of the current switch condition, and trigger the simulation software to reset the switch to off after a specified time interval. This triggering of the reset is done at the beginning of the "K" task, prior to processing it. The time interval is by aircraft type and defaults to 24 hours. However, the user may use the KTIMSW change card to input a new time interval.

If the user fails to control the switch with a "K" Mode task, the simulation software will take some default actions at End-of-Network. End-of-Network (EON) is defined as the end of network processing, that is, the last task completion. This can occur at either: (1) true End-of-Network, (2) at the sortie task for a spare aircraft, or (3) at the sortie task for an aircraft whose mission has already occurred or been cancelled. If at least one "J" Mode task was processed and the switch was partially on when reached, the switch would automatically be set fully on and the software triggered to reset the switch to OFF after the specified time interval. With the switch either ON or OFF at EON, no action is taken.

The "U" Selection Mode is effective only if the switch is fully on and a reset of it has been triggered. The "U" Selection Mode will unschedule the switch's resetting and set it off immediately upon being processed. If the switch is off, or partially on, when the "U" Selection Mode is processed, no action is taken. In all cases, the task coded with the "U" Mode will be processed as a "DO" task.

The KTIMSW can be used in either pre- or post-sortie networks. However, there is only one (1) "K" timing switch per aircraft. Once the "K" Mode task has been processed, all subsequent "J" or "K" Mode tasks in the network will not be processed unless the reset time interval has passed or a "U" Selection Mode task has been processed. Therefore, use of the feature in pre-sortie could negate post-sortie use.

RAM aircraft are returned to the simulation with the switch turned off and no switch resetting scheduled. New aircraft enter the simulation in the same manner.

Figure 27 contains a total recap of all "K" timing switch (KTIMSW) actions that can take place.

(f) L Mode - Resource Substitution by Location - This is a relatively recent addition to the LCOM software. The "L" or "Location" Selection Mode triggers a change in the location of a resource that is processing through the network. An "L" segment will have a parameter which specifies the location to transfer the resource to. (Multiple locations are allowed.)

Resource substitution by location provides the capability to use separate pools of similar resources to process a network of tasks through separate locations, without the requirement to define duplicate tasks and networks for each location. For example, a task requiring a crew chief could be defined only once, be called from a network processing three (3) different locations (such as different bases), and the software will use the crew chief from the appropriate location to process the task at each location.

The basic design of the resource substitution by location feature involved identifying resources to specific locations and using a new selection mode "L" in the Form 11s to indicate a move in the networks from one location to another.

An example of this capability is reflected in Figure 28. A mission network beginning at node "A" will be processed and result in a multiple base (location) situation. Note that the fuel and repair tasks in the network section beginning with node "F" is processed at (called from) the three (3) different locations. Each of these two (2) tasks will have only a single definition on Form 12, requiring a MAN-A and MAN-B respectively. Also, network call section "F" need only be defined once. However, MAN-A and MAN-B must be defined on Form 13 for each location they will be used at. Also, selection mode "L" must be used to identify the new locations.

The use of the Resource Substitution by Location feature involves the following actions:

(1) All resource ID names other than clock names can be a maximum of only five (5) characters rather than the six (6) characters used on LCOM II Version 3.5. The basic design involves using the sixth position of any resource ID field (or aircraft name field) on Forms 13, 16, 17, 20 or 22 to only specify the location to which the resource belongs. Any letter, number, or symbol can be used to identify a particular location. The default location is signified by a blank in the location column. This enables data bases to run through this version of LCOM easily, even if only one (1) location is being considered, by ensuring that all NONCLOCK resources have a maximum length of five (5) characters and leaving all location columns blank. Form 12 will never contain location information in the resource ID fields.

(2) The location specified on the Form 20 for the resource entering the network is the location from which the Main Module will initially obtain resources by the network tasks. Whenever a task starts, the Main Module

| PROCESSING LOCATION | SWITCH VALUE CURRENT | CHANGED TO | DIRECTED ACTION | SWITCH RESET |
|---|---|---|---|---|
| At J Task | 0 | 1 | Process J Task | N/A |
| At J Task | 1 | 1 NC | Process J Task | N/A |
| At J Task | 2 | 2 NC | Skip J Task | N/A |
| ********** | | | | |
| At K Task | 0 | 2 | Process K Task | Scheduled |
| At K Task | 1 | 2 | Process K Task | Scheduled |
| At K Task | 2 | 2 NC | Skip K Task | N/A |
| ********** | | | | |
| At End-of-Network | 0 | 0 NC | N/A | N/A |
| At End-of-Network | 1 | 2 | N/A | Scheduled |
| At End-of-Network | 2 | 2 NC | N/A | N/A |
| ********** | | | | |
| At U Task | 0 | 0 NC | Process U Task | N/A |
| At U Task | 1 | 1 NC | Process U Task | N/A |
| At U Task | 2 | 0 | Process U Task | Unscheduled |

*****************************************************************************

NOTE: NC = No Change

N/A - Not Applicable

Figure 27. KTIMSW Action Matrix.

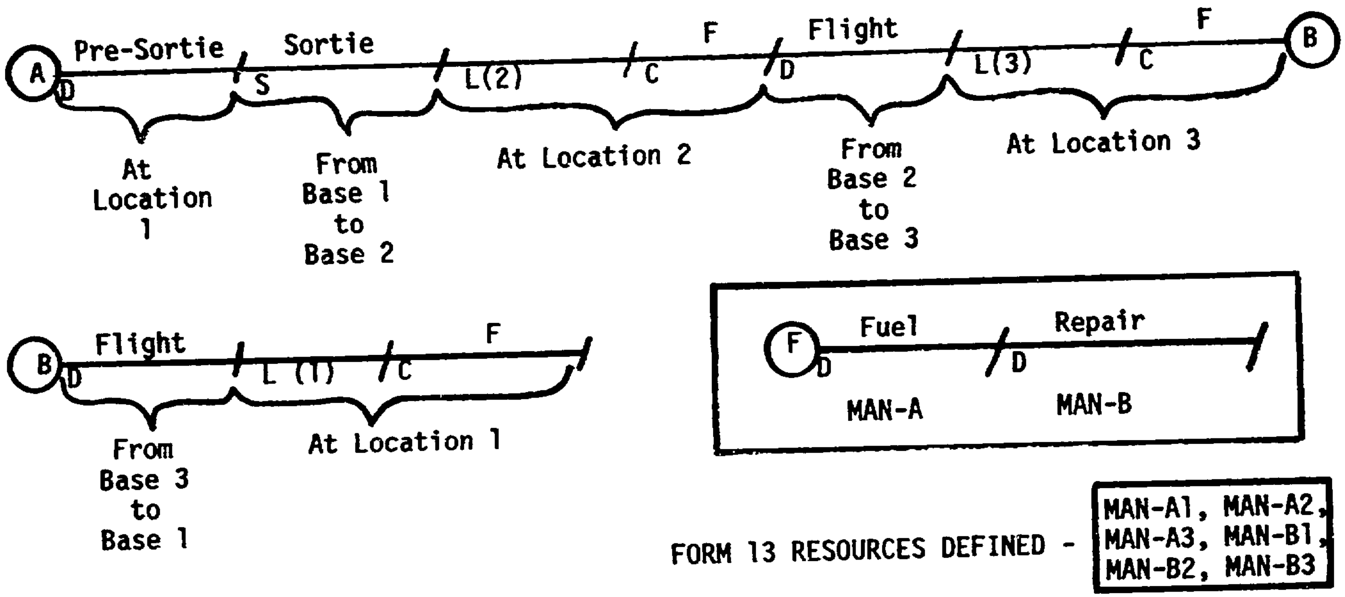



Figure 28. Example-Resource Substitution by Location.

searches for the resources required on the task, based on the location currently in effect. The location can be changed through the use of the new selection mode "L" in the Form 11s. When the resource processing through the network is to move a new location, use the "L" Selection Mode (which is treated like a ("D")), and specify the new location in the selection parameter field. The Main Module will then obtain resources for tasks from the new location's resource pools.

(3) Any resource processing through the network other than an aircraft is released to the pool of resources of the location in effect at end-of-network. Currently, aircraft of the same name at different locations are treated as different aircraft types so the Main Module will (at end-of-network) return aircraft to the pool they came from. This also means that the aircraft specified on a Form 20 must include the same location that was specified on the Form 17 in the aircraft name field for this Form 20's mission or activity name.

(4) One of the primary aims of this feature is to minimize the number of Form 11s and 12s needed to simulate a multi-location situation. However, a Form 13 must be supplied for every aircraft or non-aircraft resource at every location the resource might be used, consumed, generated or released. The Main Module will abort with a fatal message if any needed Form 13s are not present. The input Module does provide a table, listing resources versus location, where one can easily tell which resources have been defined for which locations.

(5) If any tasks are still in process or waiting to be done when a "L" is encountered in the network, the Main Module will issue a message and then wait to process the "L" until all other branches have reached end-of-network.

(6) Task specific substitutes (12A Records on Form 12) can come only from the current location, but the general substitutes (Form 13) include a location column to allow substitution between locations.

(7) At frag time only aircraft of the same type as the entering aircraft and at the same location as the entering aircraft will be considered for cannibalization.

There is no direct interface between the general and task specific resource substitution features and the resource substitution by location feature, other than the initial application of the location to the initial resource identification.

Aircraft are not the only resource that can change location. For instance, you could change the location of a part so that it could be repaired at another location. However, if it is not transferred back to the original location, the part will become one of the available resources of the second location once it is fixed. A part won't transfer back to the original location like an aircraft does.

D. SHIFT CHANGE POLICIES - LCOM FORM 16 (AF Form 2716)

A lot of flexibility has been built into the LCOM Form 16s (See Figure 29). You can make the shift patterns as simple or as complicated as you desire. The normal output from the PHASE Programs creates three eight-hour shift patterns for each AFSC with 200 men authorized on each shift. This is referred to as unconstrained manpower because you probably would never need 200 men on each shift.

If you were developing an LCOM Model in which the first five days is a surge (Maximum effort at the outbreak of hostilities) then transition to a sustained combat environment, you may want to specify 12-hour shifts for the first 5 days and then three eight-hour shifts each day for the remainder of the simulation.

If you were modelling a peacetime situation, you may want to model such situations as half of the men in the shop going to lunch for an hour. Or you may want to model peaks in manpower at shift change time caused by men reporting to work one-hour before their shift actually starts. You may also want to define additional shifts to account for a "skeleton crew" on the job during the weekend.

The following (See Figure 29) is an actual case illustrating the peacetime situation described above. AFSC 325X0 has two men working from midnight to 0800, two men working from 0800 to 1600 and four men working from 1600 to 2400 daily. A skelton crew of one man on each shift is working on the weekends.

A total of 14 shifts are defined. The first 12 shifts are repeated daily for five days then the last two shifts are repeated daily for two days. The number of men on the second, sixth and tenth shifts are cut in half to simulate each half of the shop going to lunch for one hour. The number of men on the fourth, eighth and twelfth shifts simulate the shift overlap. The thirteenth and fourteenth shifts simulate the weekend skelton crew.

| LOGISTICS COMPOSITE MODEL | | | | | | | | | | | | | | | | | LCOM II - SIMULATION MODEL INPUT - SHIFT CHANGE POLICIES |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CARD I.D. | CODE | REP NO | RESOURCE I.D. | SHIFT DURATIONS/AUTHORIZATIONS 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| 16 | | | | | | | | | | | | | | | | | |
| | * | | | 3 | 2 | 2 | 1 | 3 | 2 | 2 | 1 | 1 | 2 | 4 | 1 | 8 | 16 |
| | R | | | | | | | | | | | | | | 5 | | 2 |
| | | | 325X0 | 2 | 1 | 2 | 4 | 2 | 1 | 2 | 6 | 4 | 2 | 4 | 6 | 1 | 1 |

AF FORM 2716 (1) CODE: * = New Policy, R = Repeat (2) Repetition number = zero or blank thru 9. (3) Resource location column, or blank.

Figure 29. Shift Change Policies - LCOM Form 16.

SECTION VI

NETWORKING

## A. GENERAL

The procedures to be used in defining task names, using LCOM prefixes, node names, clock names, resource definitions and some general guidance in LCOM networking will be discussed in this section. These coding and networking conventions will be followed when applicable regardless of which data processing programs are used to analyze and compile maintenance data collection data. Figures 30 and 31 give examples of basic network logic.

a. Task Names:

(1) Task names for scheduled maintenance, and tasks that take place on the flightline that are not related to a Work Unit Code (WUC) will consist of a one (1) digit LCOM action code prefix and a descriptive abbreviation of the action being performed. However, those tasks that can be described very clearly with six (6) characters or less need not have the LCOM action prefix. For example, preflight could be "PREFLT", aircraft fueling could be "FUEL", and the aircraft sortie could be "SORTIE". Scheduled time change removals should utilize the unscheduled removal task name, or carry an "S" in the last position if different time or resources are required. Where the scheduled maintenance task corresponds directly with a special inspection (04000 series WUC) that code should be used in place of a descriptive task name.

(2) Phase tasks will be coded with the prefix PH. When networked by phase, tasks will be coded to reflect the number of the phase and, when used, the phase card being checked. For example, work to perform the phase inspections of card 23 in phase 4 would be coded PH0423, PH for phase inspection, 04 for phase 4, and 23 for card 23. Common phase tasks should be prefixed with PH followed by a short description of work being done, for example, "PHPREP" could represent preparation of aircraft going into phase.

(3) Task names for unscheduled maintenance should consist of an LCOM action code followed by the WUC. The last position of the task name may be used to further identify tasks when networking at the three (3) or four (4) digit WUC level. For example, if there were two (2) basic remove tasks shown on the aircraft for the 71200 WUC area (perhaps performed by different specialists) one would be coded R71200 and the other R71201.

(4) LCOM Action Codes: (Reference Figures 30 and 31 for a schematic example of LCOM action codes and networking).

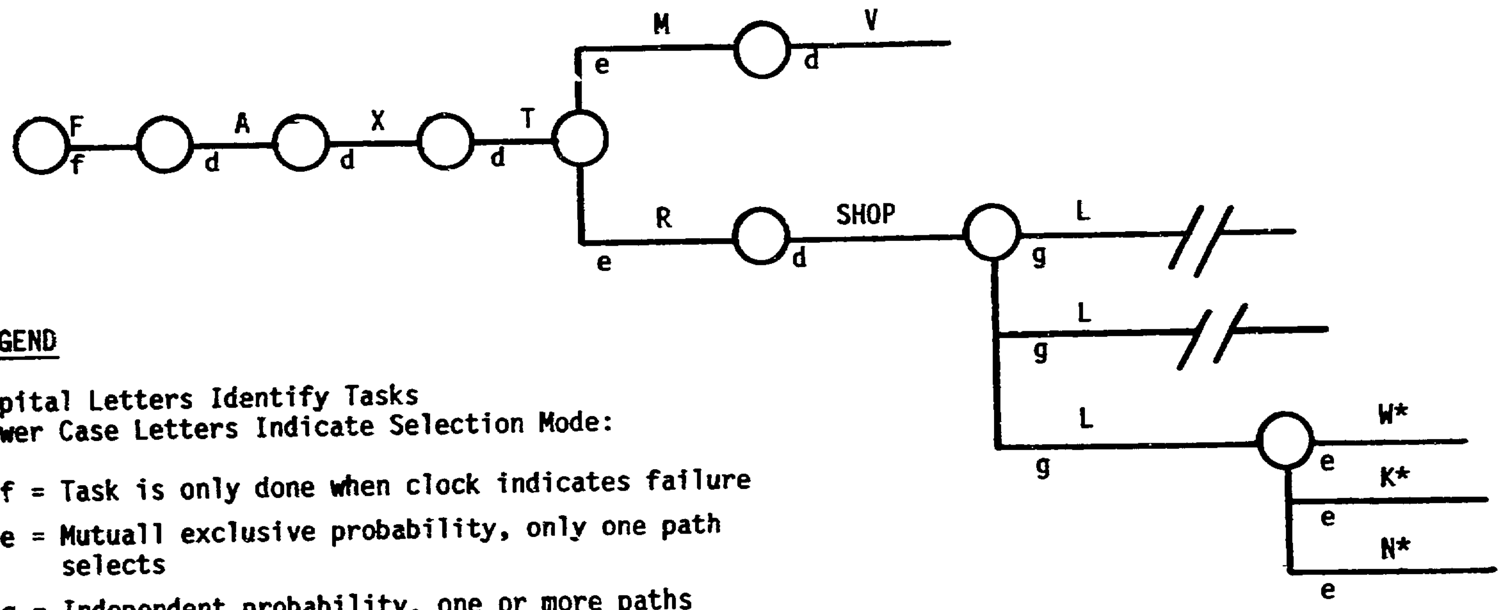
(a) Standard LCOM action codes for on-equipment networks:

F = Failure Clock

T = Troubleshoot

X = Work to facilitate maintenance, (including Access, Jacking, etc.)

A = Get and Hook Up Aerospace Ground Equipment (AGE or support equipment)




LEGEND

Capital Letters Identify Tasks
Lower Case Letters Indicate Selection Mode:

f = Task is only done when clock indicates failure

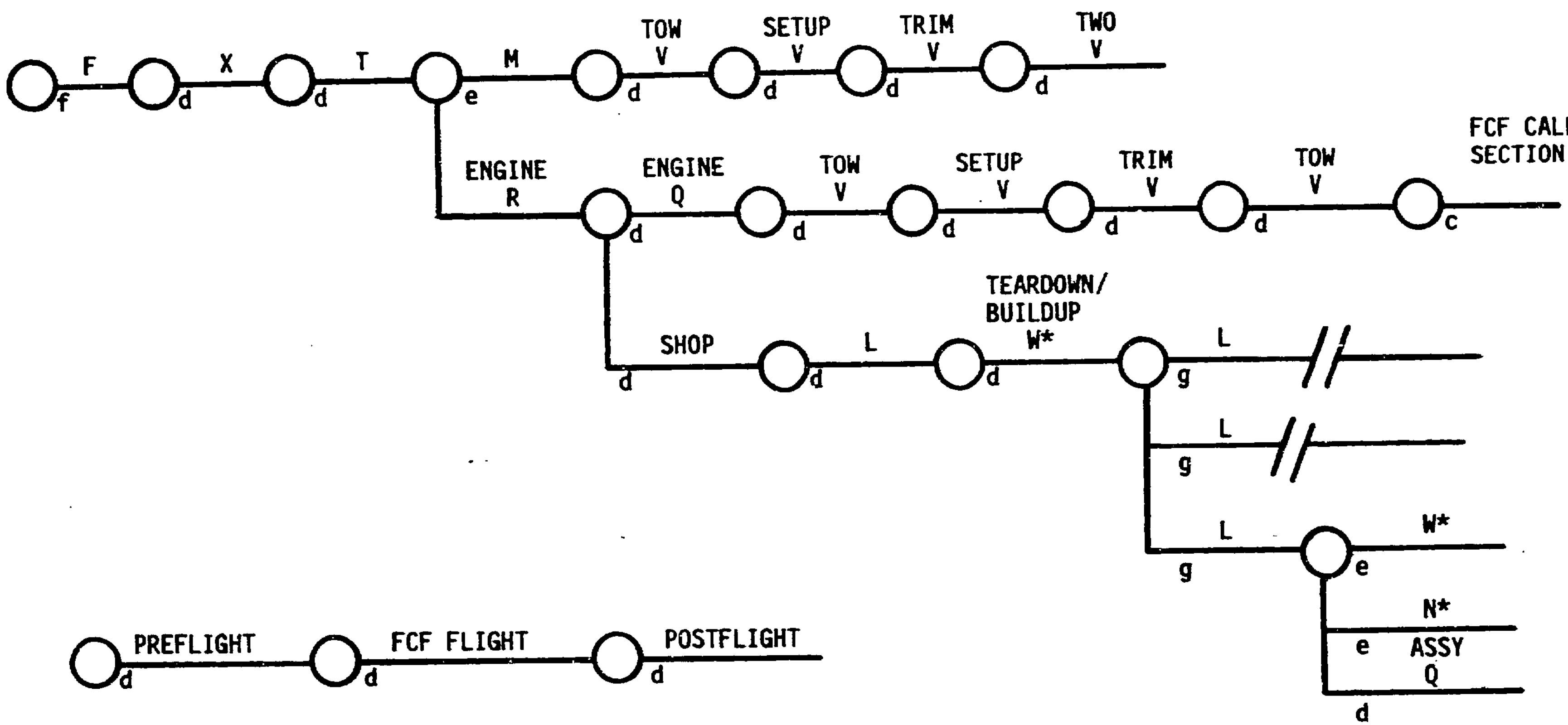
e = Mutuall exclusive probability, only one path selects

g = Independent probability, one or more paths selected

d = Task is always done

* = This and any subsequent work is on the LRU, and releases constraint on the next higher assembly

Figure 30. Schematic of Maintenance Network Basic Logic.




LEGEND

(Same as for Figure 30)

Figure 31. Schematic of Engine Network.

R = Remove and Replace Component

H = Inspection

M = Repair (on aircraft)

V = Verify System Works

J = Aircraft Handling (towing, etc.)

C = Call Section

D = Decrement Failure Clock

B = Loading/Downloading

Z = Fly Sortie

Q = Draw Component from Supply or Cannibalize

(b) Standard LCOM Coding for in-shop work:

L = Component Identification

W = Check and Repair of a Component

K = Check OK

N = Check and Not Reparable This Station (NRTS) Condemn [now referred to as Not Mission Capable Supply - NMCS]

Y = Disassemble/Reassemble

(5) To enable proper compilation of statistics in the simulation, one of seven codes are used to designate each task in the network. These Task Type Codes are input on the Form 2719 (Extended Forms 11), or on the Form 2712 (Forms 12). These Task Types are:

Type 1 - Used to designate a sortie task.

Type 2 - Used to designate a task that involves unscheduled maintenance.

Type 3 - Used to designate a task that involves scheduled maintenance.

Type 4 - Used to define the first depot repair task in the parts network. This should be the first task after leaving the base, normally the order and ship delay task. This task type is equivalent to Type 2 except that it is needed to produce post processor data and ensure the shop repair and the Not Reparable This Station (NRTS) statistics in the Performance Summary Reports (PSR) are correct.

Type 5 - Used for other tasks, such as delays. The statistics for these tasks are not accumulated.

Type 6 - Used to define a parts condemnation task at either base or depot level within the parts network. The part completing a task with this type code is consumed and removed from the simulation. No other task can follow a Type 6 task.

Type 7 - Used to define the first base repair task in the parts network. This task type is also equivalent to Type 2 and is needed to produce post processor data.

NOTE: Task Types 4 and 7 cannot be used in series.

b. Definition of LCOM Action Taken (AT) codes are relatable to maintenance action taken codes reported on AFTO Form 349.

| LCOM AT CODE | INCLUDES |
|---|---|
| M | F, G, J, K, L, V, and Z maintenance action taken codes on aircraft. |
| R | R and P action taken codes (excluding those with HOW MAL codes 799, 800, and 801). |
| T | Y action taken code (excluding 799, 812, and 948 HOW MAL codes). |
| X | S action taken codes and P action taken codes with HOW MAL codes 799, 800, and 805. |
| H | H action taken codes and Y action taken codes with HOW MAL codes, 700, 812, 948. |
| V | X action taken codes on equipment. |
| W | A, G, J, L, V, Z, M, N, C, F, action taken codes off equipment. |
| K | B and X action taken codes off equipment. |
| N | D, 1, 2, 3, 4, 5, 6, 7, 8, and 9 action taken codes. |

c. For new weapon systems, the contractor supplied Logistics Support Analysis Report (LSAR) should be used. This LSAR provides contractor estimates to the shop replaceable unit (SRU) level. It is updated as the acquisition progresses.

The most important LCOM-related data obtained from the LSAR is the manfacturer's estimate of the Mean Time Between Maintenance Actions (MTBMA). This parameter combines the minor maintenance, 'remove-and-replace", and "can-not duplicate" actions. The actions required to compute the MTBMA are the standard reliability failures (Type 1, 2, and 6). [Refer to AFR 80-5 for more information.] This value is used in the determination of the unscheduled maintenance failure clocks for "on-equipment" or "off-equipment" actions in the model.

d. Node Names:

(1) Main Networks (flightline networks) should be prefixed with MN followed by 0001 and listed sequentially. For example, MN0001, MN0002, MN0003, etc. If more description is wanted to define mission type or action being accomplished, a short abbreviation can follow the MN prefix. For example, the functional check flight networks would be MNFCF1, MNFCF2, etc., and the weather cancel networks could be MNWX01, MNWX02, etc. Scheduled and special inspection networks will be prefixed with SI. Phase networks will be prefixed, PH followed by the phase number, if used. For example, nodes for phase 4 would be PH4001, PH4002, PH4003, etc. Common phase networking would be PH0001, PH0002, PH0003, etc.

(2) Unscheduled maintenance node names are derived directly from the WUC. The first digit of the WUC is converted to an alpha character. For example, the 11 WUC area would be represented by A, 23 by B, 45 by D, 72 by G, etc. The second and third digit of the WUC would follow the alpha character. The fourth, fifth, and the sixth digits of the node name is optional. However, the user should use a naming technique that allows the flow of work to be followed from one task to the next. For example, node names for work being performed on WUC 11120 could be coded A11200 followed by A11201, A11202, A11203, etc. The Automatic Network Generator (ANG) follows this naming convention.

e. LCOM clock names:

(1) Unscheduled maintenance clock names should be six (6) digits, with an "F" in the first position and WUC in the following five (5) positions. If more than one clock exists for the same WUC, the last position should be used to distinguish them. For example, F72A00 could indicate the failure clock for postflight maintenance and F72A0L could indicate the failure clock for quick maintenance at Launch.

(2) Other failure clocks should be identified by an "F" in the first position and a descriptive abbreviation, as appropriate. (A "Z" is used on the Extended Form 11s to delink the clock from CALLS1 when the PHASE programs are run).

(3) Halt clocks should be identified by an "H" in the first position and WUC or description abbreviation, as appropriate.

f. LCOM resources name

(1) Manpower resources are identified by the five (5) digit Air Force Specialty Code (AFSC) (excluding shred). Where the same AFSC works in different post manning situations, different work centers, different locations, or has shreds that need to be separately identified, the fourth (skill level) position of the AFSC is used to carry distinguishing alpha codes. The last character (sixth position) will be used for the "Resource by Location" capability.

Suggested Codes for typical breakout are:

462G0 = Gun Services

462W0 = Weapons Release

462L0 = Weapons Loading

431R1 = End of Runway

431A1 = Alert

431P1 = Phase Dock

431C1 = Aero Repair

431X1 = Flightline Service

(2) No standard is established for AGE resource names at this time.

(3) Parts are identified by WUC.

g. Naming conventions for multiple aircraft and/or multiple base simulations:

(1) Task names may utilize an alpha equivalent in either or both of the first two work unit code (WUC) positions to distinguish tasks performed on a second aircraft type or at different locations.

(2) Node names may use any combination of numerics or alpha equivalents in the first two WUC positions.

(3) Resource names and clock names may use alpha equivalents in the first two work unit code positions.

h. General considerations in developing LCOM networks:

(1) Network with the least number of clocks and tasks necessary to accomplish the objectives of the study. Separate tasks are required, as a minimum, wherever there is a difference in task resource requirements. Avoid overly complicated networking logic unless it makes a measurable difference in output statistics or simulation efficiency.

(2) Use separate networks for tasks with different distributions of time or frequency where such differences could impact sortie generation. For example, the repair of failures that are found only when the aircraft is torn down for phase inspection should only be shown in phase networks, and not lumped together with flightline dispatches. Where different maintenance procedures with significantly shorter task times are used to correct failures discovered at launch, they should be shown in separate networks than are used for postsortie maintenance. Where procedures and times are similar, tasks performed at different points in time may process through the same networks. In this case, the relative frequency of occurrence at each point is controlled by decrementing values established on the basis of "when discovered" code data, provided that no single decrement value exceeds the value of the decremented clock.

(3) A primary advantage of LCOM is the ability to relate

maintenance demands to specific mission requirements through the failure clock and decrementing mechanism. Failure clocks should be used to drive maintenance frequency wherever maintenance is a function of equipment usage (flying hours or sorties) or elapsed operating time (as in a phase inspection). The clock values and decrements should be in terms of the most direct measure of usage that can be obtained (sorties by mission type, operating hours, rounds fired, etc.).

(4) Tasks which cannot be done concurrently with other tasks should be networked in sequence (or in sequential call sections). Examples are engine run-up, defueling, and jacking. Where there is a high probability that more tasks will be processed in parallel than space limitations around the aircraft will allow (as in loading and servicing on turnaround), tasks may be grouped into two or three linear strings of call sections. The extent of parallel versus sequential networking can have a significant affect on aircraft turnaround time and on the timing of peak manpower demands. In some instances, it is appropriate to allow tasks in parallel, but force them into an optimal sequential order by resource constraints. For example, a large number of preflights may be scheduled at one time, but will be done in sequential order if only a few crew chiefs are provided.

(5) Care must be taken to use the consume and generate logic properly. The generate task (asterisked task) releases the primary resource (e.g., aircraft) and causes a new resource to be generated which then proceeds through the network. Consumes and generates are a powerful logic mechanism to create dependencies between otherwise separate missions or networks, to temporarily remove a failed resource from the simulation so it cannot be used or preempted, and to keep account of resources transferred from one location to another. However, consumes and generates for each resource must remain in balance for a stable simulation run.

B. MAIN AIRCRAFT SERVICING NETWORKS

(1) Content and Data Sources: - At this point it would be a good idea for the reader to go back and briefly review Figure 3. The Form 20 described in Section III, specifies when missions are to be flown and their preparation leadtime. (Refer to AFMSMET Report 78-5.1) This controls when servicing and maintenance jobs must start. The task sequences, the resources needed, and the time it takes to do the work are put into the model in network format. The form that ASD uses to input this data is the AF Form 2719, Extended Form 11 (See Figure 32).

The main aircraft servicing networks cover work done by the organizational maintenance squadron and the munitions maintenance squadron load teams in launching and recovering aircraft. They also include certain scheduled inspections and service work by other specialists that is regularly done in conjunction with preflight or post flight inspections.

Maintenance data collection (MDC) data on similar systems is not much help in modeling munitions, loading, or crew chief work. However, HQ TAC's report "Modeling Procedures for Munitions Storage/Handling and Buildup", dated 1 Nov 81, could provide some help in the munition's area. Work unit codes for this area are not detailed enough, and the level of reporting is not that accurate. The operations concept for the new aircraft is a better starting point. The

INPUT No. 2

EXTENDED FORM 11

| [illegible] | Prior Node | ACT | WUC | Next Node | [illegible] | Sel. Mode | Put Decimal MSBF or Probability | NCLOK Clock No. | Release | Type Task | Priority | [illegible] (Tenths) | VAR | Dist. Type | [illegible] | N | DEC(1) OR AFSC/AGE | N | DEC(2) OR AFSC/AGE | N | DEC(3) OR AFSC/AGE | N | DEC(4) OR AFSC/AGE | Continuation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

AF Form 2719

PUNCH CARD TRANSCRIPT

Figure 32. AF Form 2719 - Extended Form 11.

requirements office at the operating command headquarters can assist in translating an operations concept into specific assumptions and task sequences. For example, do aircraft have to be towed into shelters when they land or do they taxi to revetments? If towed, will three-man or five-man tow teams be required? If they taxi, who guides them in and parks them? Taxi time and maintenance travel time could depend on the distance revetments are dispersed. What kind of fueling facilities will be available? Will aircraft taxi right to fueling pits, or wait for a truck to come around during postflight?

Visit an organizational maintenance squadron at a base flying aircraft of the same type and similar mission, and discuss in detail what they do, who does it, and in what order. Aircraft servicing tasks and sequences tend to be generally similar in the same command, and more so for aircraft flying the same type of missions. The preflight and postflight technical orders (checklists) for similar aircraft should be reviewed for similarities and differences with the new aircraft. The time estimates obtained from experienced line and crew chiefs on similar aircraft can then be adjusted for these differences, to get task estimates for the new aircraft. Published munitions loading standards can be useful data sources where loads, release mechanisms, and loading heights are comparable. Again judgement must be used to factor for identified differences. Many safety standards and policies will apply across all aircraft in a command. A detailed review of the 04 series of special inspection work unit codes listed in the 06 technical manuals for aircraft of the same type can suggest many inspection tasks that may be applicable. Service and inspection requirements identified by the contractor should be evaluated and included. However, contractor task times and crew sizes usually depict touch times rather than the time people are tied up on the job, and their crew sizes may not reflect actual practice. Experienced maintenance technicans from the operating command who have had a chance to observe maintenance on prototypes or test aircraft are a better source of information and provide more realistic estimates.

The access necessary in order to do each task should be analyzed as soon as mockups, prototypes, or test aircraft can be seen. Access is peculiar to the new aircraft design and cannot be identified from data on other systems. For example, the A-10 manning requirement was reduced by providing an easier way to get an engine oil sample during postflight. This change was made at an early mockup review before the design was firm. Main network tasks should be given a lot of attention because they can have the biggest impact on manning. Cutting one man off a maintenance crew or saving time by an easier access, can have a big payoff in the manning that will finally be required.

(2) Coding the Networks:

(a) General - A Network names the tasks that have to be accomplished, and shows the order in which they are to be done. It also identifies the time and resources needed for each task. Nodes or connection points specify the task processing sequence to the computer. However, every task does not always have to be done in the same sequence. Doing a task can be made contingent on a probability or on the occurrence of some other simulation event.

Network data is entered on an Extended Form 11 (AF Form 2719). The use of the Extended Form 11 in building a data base in lieu of using the LCOM forms has the following advantages: (1) less forms to prepare and have keypunched; (2) less time required to quality control keypunch output; (3) the basic data base can be built faster; and (4) storage of the data is more compact. It is not the complete solution. Phase output requires the addition of LCOM Forms 17, 21, 22, and 23 and the completion of the Forms 14, 10, 12 (If Form 12 is required) before the initialization can be run.

The Extended Form 11 program takes user prepared data, task names, task times, resources, and reliability data imprinted on one form and generates the Forms 10s, Form 11s, Form 12, Form 13s, Form 14s, Form 16s and Form 18s, from the PHASE program.

The following information is taken from "Extended Form 11 Processor User Reference Manual", dated August 1979. A single main network includes all the flightline schedule maintenance tasks performed before and after sorties. This network also includes CALLS1 tasks to call up most unscheduled maintenance. Unscheduled maintenance is modeled in networks generally corresponding to systems or subsystems.

Unscheduled maintenance networks begin with an "F" task that defines the failure clock (but has no time or resources) followed by tasks defining subsequent flightline and shop corrective actions. The variable NCLOK is used for PHASE program processing and then discarded.

Task time and resources must be defined for each task the first time that the task appears in a network. The PHASE program generates a Form 12 for the task the first time it is encountered. Any subsequent uses of the same task anywhere in the model are entered with time and resources blank.

(b) Extended Form 11 Field Description - There are three (3) basic formats used to interpret the Extended Form 11. The first is for header cards, the second is for failure and halt clocks, and the last is for the rest of the task networks.

Figure 33 gives field description for each format. The card column fields of the Extended Form 11 are self-explanatory, but the user has to have some knowledge of how the program works in building the other forms, i.e., when an asterisk is placed in card column 39, what resource identification is going to be printed on the Form 12? The networker filling out the form should know when parts are being consumed and generated properly. Therefore, he should realize that the part defined on the header card is going to be shown on the LCOM Form 12. The detailed data needed to accomplish the Extended Form 11 is dependent upon the program processing the data; therefore, no details on the preparation of the form are included here.

Figure 34 is an example of a network coded on (Figure 34) Extended Form 11 with its network schematic (Figure 35) to show the use of the network coding that has been standardized.

The PHASE program will make the following shortcuts or assumptions in its processing:

(a) A PDEPOT task will be added to the end of all shop tasks with LCOM action code "N" and followed by a blank node.

(b) All failure clocks, not starting with a "Z" will be connected to CALLS1. The stringing will occur in groups of ten starting with node 100 and going to 101, 102, etc.

(c) Decrementing tasks are not put on the Form 14s. They must be put in before running the INPUT module.

(d) Resource substitution by location and resource substitution by itself, cannot be handled. For resource substitution by location, the "L" selection mode and parameter are recognized, but the user must mannually insert the appropriate Form 13s.

(e) Alternate resource groups using Form 12As must be manually inserted, if desired.

(f) A resource that my enter a network must be specified by the user on the Form 13.

(g) Only nine clock decrements can be specified.

(h) The quantity per aircraft (QPA) is permitted on the Form 13s for parts. There is no method for the user to specify this number on the Extended Form 11s.

(i) If multiple header cards are used, only the last comment appearing in the string of Extended Form 11s (per NCLOK) will be placed as comments on the Form 11s generated by PHASE.

(3) Coding Network Call Sections:

(a) General - A call task is a dummy representing all the tasks in a section of network. All applicable tasks within the section must be done before the call task can be completed or any following task started. Tasks which can be done in parallel, but where all constrain some subsequent task, are coded in call sections. In ASD LCOM, no parallel tasks can precede a sortie, unless they are in a call section. Call sections are also useful where the same group of tasks is repeated in several networks. The call section tasks are defined in the first place the call appears, and then just the call task is used to represent the section later.

The call task is represented by selection mode of "C". It is used in the network where the request originates.

Any number of tasks can be defined in a call section, from one by itself to hundreds in many parallel strings. A call section can request another call section, just as in computer programs, subroutines, external to the main program, can be accessed. Note that a specific call task name must only be defined once in the entire model, at the first place it appears. After that, only the call task name is used to represent all the tasks in that call section.

(b) Using Call Sections for Unscheduled Maintenance - The relationship between the main networks and unscheduled maintenance networks is shown in Figure 3. Aircraft break as a result of flying. The failure clocks, and the unscheduled maintenance work to fix broken aircraft, are defined in call sections. Corrective maintenance tasks are only called where the failure clocks indicate something is broken. If nothing is broken, or when repair has been completed, the program will continue to process the next main network task.

Record Type 1 -- Header Card Description.

| COLUMN | MODE | DESCRIPTION |
|---|---|---|
| 13 - 17 | A | Line replaceable Unit (LRU), optional. |
| 25 | A | Required character H to indicate header card format. |
| 24 - 38 | A | Current network clock name, required. |
| 42 - 80 | A | Remarks to be printed on LCOM Form 11 cards. |

NOTE: Header cards may be used throughout the clock network as comment cards. For those users who also wish to use the Expected Value Model (EVM), check the EVM User Reference Manual for additional information required on the header card.

Record Type 2 -- Failure on Halt Clock.

| COLUMN | MODE | DESCRIPTION |
|---|---|---|
| 5 - 10 | A | Prior node. |
| 12 | A | Action taken code Z is used if the clock is not to be chained to CALLS1. |
| 13 - 17 | A | Work Unit code. |
| 19 - 24 | A | Next node. |
| 26 | A | Selection mode (F or H). |
| 27 - 32 | R | Mean sorties between R, M, or H actions (MSBF). |
| 34 - 38 | A | Network clock name (NCLOK). |
| 39 | A | Release field -- must be blank. |
| 40 - 41 | A | Task type and priority. |
| 48 - 50 | I | Percent variance to be used on the MSBF field to compute the variance for LCOM Form 13. |
| 51 | A | Distribution type must be non-blank if the percent variance field is non-blank. Default for halt is "C" and for failure clock is "X". |

Figure 33. Extended Forms 11 Description.

1

Record Type 2 -- Failure or Halt Clock. (Continued)

| COLUMN | MODE | DESCRIPTION |
|---|---|---|
| 52 | A | Time unit for MSBF field. If blank, no time unit is placed on LCOM Form 13. |
| 54 - 58 | R | Decrement field -- this first field must have a number for "F" selection mode. A halt clock defaults to 1.0. |
| 61 - 65 | R | Decrement field for LCOM Form 14. |
| 68 - 72 | R | Decrement field for LCOM Form 14. |
| 75 79 | R | Decrement field for LCOM Form 14. |

Record Type 3 -- Other Network Cards.

| COLUMN | MODE | DESCRIPTION |
|---|---|---|
| 5 - 10 | A | Prior node. |
| 12 | A | Action taken code. |
| 13 - 17 | A | Work Unit code. |
| 19 - 24 | A | Next node. |
| 26 | A | Selection mode. |
| 27 - 32 | R | Probability. |
| 34 - 38 | A | Network clock name. |
| 39 | A | Release, may be blank, *, or #. |
| 40 - 41 | A | Task type and priority. |
| 43 - 47 | A | Average task time in tenths of hours unless HH+MM or *1 format is used. (See column 52). |
| 48 - 50 | I | Percent variance. |
| 51 | A | Distribution type. |

Figure 33. Extended Forms 11 Description (cont'd)

2

Record Type 3 -- Other Network Cards. (Continued)

| COLUMN | MODE | DESCRIPTION |
|---|---|---|
| 52 | A | Time unit for time field, columns 43-47. If this is blank, the unit is set to tenths of hours for LCOM Form 12 unless the HH+MM or *1 format is used. This value may be D, H, or M. |
| 53 | A | Crew size for the following resource. |
| 54 - 58 | A | AFSC or AGE requirement. |
| 60 | A | Crew size for the following resource. |
| 61 - 65 | A | AFSC or AGE requirement. |
| 67 | A | Crew size for the following resource. |
| 68 - 72 | A | AFSC or AGE requirement. |
| 74 | A | Crew size for the following resource. |
| 75 - 79 | A | AFSC or AGE requirement. |
| 80 | A | Resource list to continue flag. |

NOTE: Columns 12 - 17 serve as the task name.

Figure 33. Extended Forms 11 Description (concluded)

3

INPUT No. 2

EXTENDED FORM 11

UNSCHEDULED MAINTENANCE NETWORK USING CODING CONVENTION TO SECOND INDENTURE

| Prior Node | ACT | WUC | Next Node | | Sel. Mode | MS2F or Probability | NCLOX Clock No. | Release | Type Task | Priority | Hours (Tenths) | % VAR | Dist. Type | N | AFSC/AGE | N | AFSC/AGE | N | AFSC/AGE | N | AFSC/AGE | Continuation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | H | | | 14A10 | | | | UM FLIGHT CNTRL X MECHANISM | | | | | | | | | | | |
| A4A101 | F | 14A10 | A4A102 | | F | 38 | 14A10 | | 2 | 1 | | | | | | | | | | | | |
| A4A102 | M | 14A10 | | | E | 74 | 14A10 | | 2 | 1 | 15 | 29 | L | | 1421X2 | | | | | | | |
| A4A102 | R | 14A10 | A4A103 | | E | 26 | 14A10 | | 2 | 1 | 25 | 3 | N | | 2421X2 | | | | | | | |
| | | 14A11 | | H | | | 14A10 | | | | UM ON PART 14A11 | | | | | | | | | | | |
| A4A103 | L | 14A11 | A4A104 | | G | 04 | 14A10 | | 2 | 1 | | | | | | | | | | | | |
| A4A104 | Q | 14A11 | | | D | | 14A10 | | 2 | 1 | | | | | | | | | | | | |
| A4A104 | W | 14A11 | DELAY | | E | 20 | 14A10 | * | 2 | 3 | 8 | 8 | N | | 1421X2 | | | | | | | |
| A4A104 | K | 14A11 | DELAY | | E | 23 | 14A10 | * | 2 | 3 | 13 | 25 | N | | 1421X2 | | | | | | | |
| A4A104 | W | 14A11 | A4A105 | | E | 57 | 14A10 | * | 2 | 3 | 15 | 29 | L | | 1421X2 | | | | | | | |
| | | 14A12 | | H | | | 14A10 | | | | UM OF 2ND INDENTURE PART 14A12 | | | | | | | | | | | |
| A4A105 | L | 14A12 | A4A106 | | A | 27 | 14A10 | | 2 | 3 | | | | | | | | | | | | |
| A4A106 | G | 14A12 | | | D | | 14A10 | | 2 | 3 | | | | | | | | | | | | |
| A4A106 | W | 14A12 | DELAY | | E | 18 | 14A10 | * | 2 | 3 | 10 | 29 | L | | 1421X2 | | | | | | | |

AF FORM 1530 PREVIOUS EDITIONS OF THIS FORM WILL BE USED UNTIL STOCK IS EXHAUSTED

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Figure 34. Unscheduled Maintenance Network Example of the Use of the Extended Form 11.

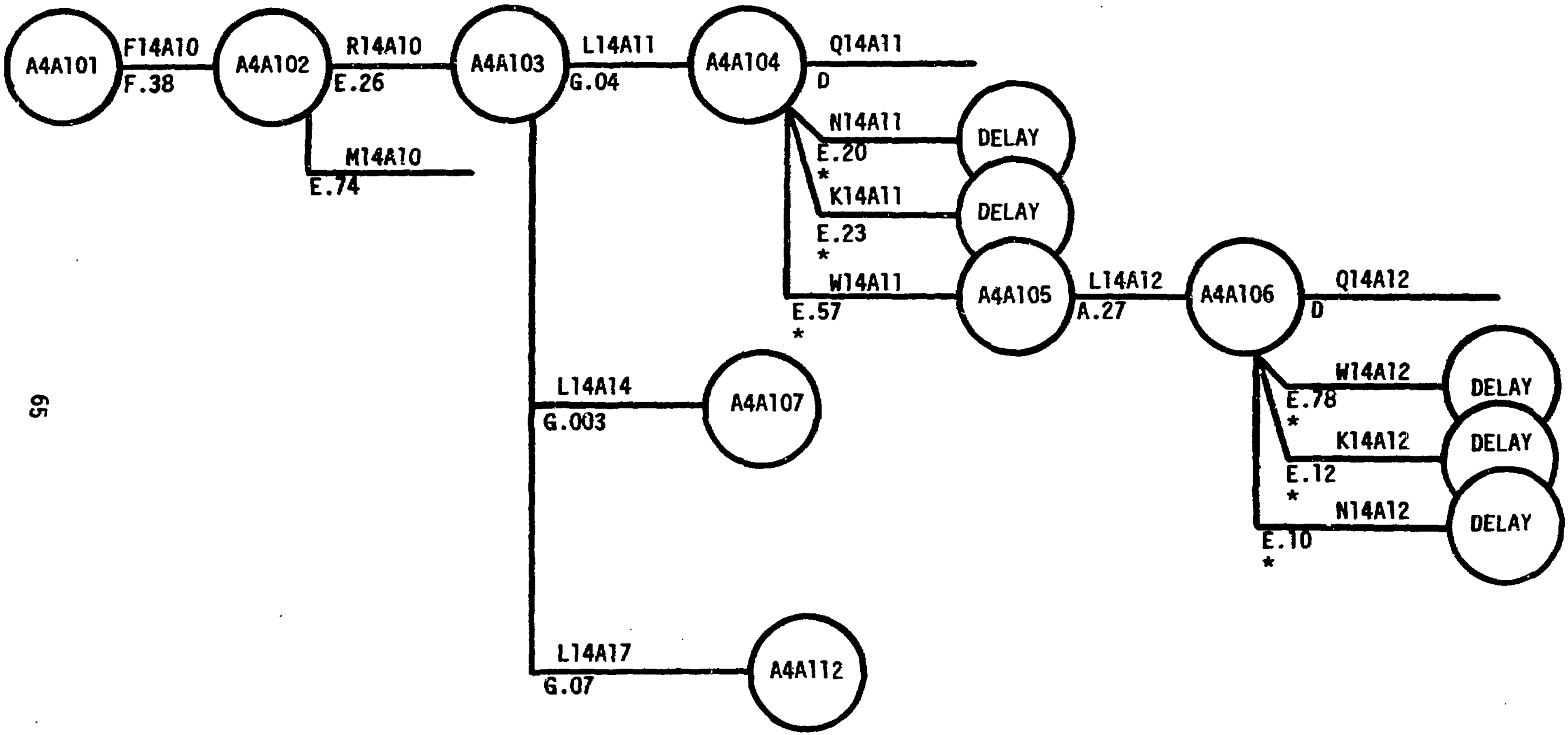



Figure 35. Network that is Coded in Figure 34.

All unscheduled maintenance that could be done concurrently is usually defined in a single large call section named CALLS1. The data base processing programs automatically provide the necessary starting tasks to define CALLS1. Unscheduled maintenance that would conflict with other work and must be done by itself is shown in separate sequential call sections. Examples, of such work are repairs requiring aircraft jacking, or towing to a test cell for engine runup.

When failures are discovered on a loaded aircraft just prior to a sortie, the munitions must be dearmed (cartridge ejectors removed) before any maintenance work is done. In some cases, such as jacking or engine runup, the ordinance may have to be off-loaded. This can be modeled using F-task stringing as described in Section V, paragraph C 4 (a).

Decrement tasks are inserted in the main networks to show where failure clocks are to be decreased. The appropriate decrements advancing the clocks must precede the unscheduled maintenance call sections that check to see if there is a resulting failure. Decrements can be defined to advance clocks by a whole sortie or fractions of a sortie, and can be setup to advance some clocks and not others. Each uniquely named decrement task advances a particular set of clocks by a specific amount.

Usually, decrement tasks are coded on the Extended Forms 11 with a task name DCRMT and a unique number, with the "D" starting in column 12. The selection mode in column 26 is "D", and probabilities and resources are left blank. However, any task may be used to decrement a clock. The Form 14 is used to list the failure clocks, the decrementing task, and their appropriate decrement.

## C. PREFLIGHT TO POSTFLIGHT NETWORK EXAMPLE

The remainder of this section illustrates main network coding and construction using a number of detailed examples of situations that were encountered in developing LCOM models for tactical aircraft. Figure 36 is the preflight and postflight network for an A-7D, and Figure 37 shows how it is coded on the Extended Form 11.

It takes one crew chief an average of 3.6 hours to preflight (HPRFLT) an A-7. They do not double up to shorten the time, even in combat, although this could be done. LOX (HLDXSV), nitrogen and air (HNARSV) are serviced during preflight. These are shown as separate tasks because different people do the work. The crew chief removes the LOX bottle and places it at the nose wheel if it needs refilling. It is needed on about 40% of the preflights so this task is coded with an "A" selection mode with a probability value of .40. On the other 60% it will be skipped. To service LOX, one 431X1 goes around and picks up the bottles. Another 431X1 refills two (2) at a time, taking an average of 15 minutes per bottle. This task is shown as requiring two (2) 431X1s for two hours using one (1) LOX servicing cart (LCART). Two (2) other 431X1s take a service cart (MCART) to each aircraft during preflight to replace nitrogen bottles as required, and to service tire air. This task (HNARSV) requires two (2) 431X1 APGs (Airplane General) for .2 hours per aircraft. Since nitrogen and air are checked every time, selection mode "D" is used. Since the crew chief preflight (HPRFLT), LOX service (HLOXSV), and nitrogen/air service (HNARSV) are parallel tasks constraining start of the next main network task, loading (BLODR4), they must be coded in a call section.

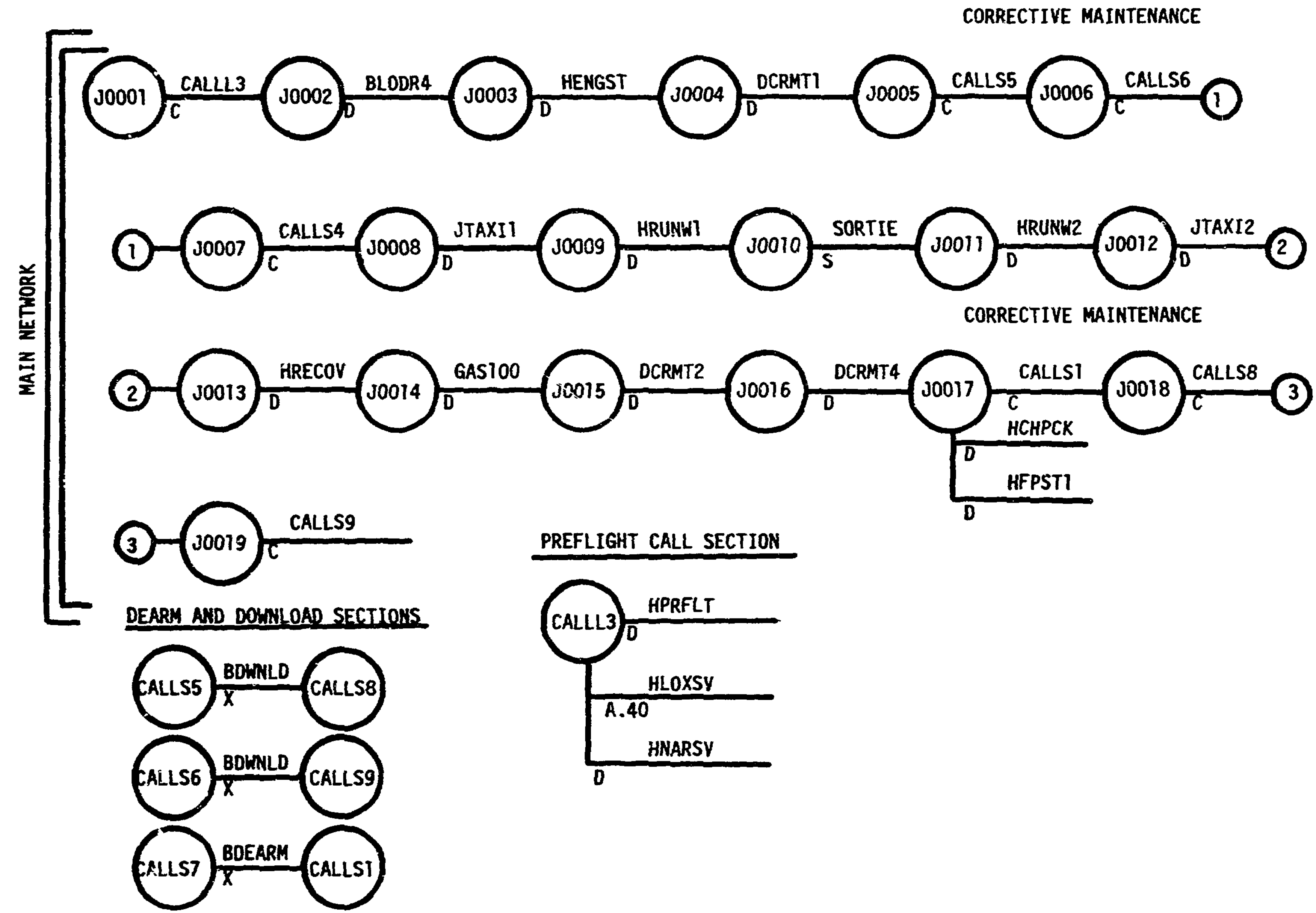



Figure 36. Example of Preflight to Postflight Main Network.

INPUT No. 2

EXTENDED FORM 11

| Prior Node | ACT | WUC | Next Node | Sel. Mode | PCT DECIMAL MSSF or Probability | MCLOCK Clock No. | Type Task / Priority | TIME (Tenths) | VAR | DEC(1) OR AFSC/AGE | DEC(2) OR AFSC/AGE | DEC(3) OR AFSC/AGE | DEC(4) OR AFSC/AGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | H | | | | AA02 PREFLITE TO POSTFLIGHT | | | | | |
| J0001 | | CALLL3 | J0002 | C | | 00010 | 31 | | | | | | |
| CALLL3 | | HPRFLT | | D | | 00010 | 31 | 36 | 29L | 1431X1 | 1BG0 | 1LADER | |
| CALLL3 | | HLOXSY | | A | .40 | 00010 | 31 | 2 | 29L | 2431X1 | 1LCART | | |
| CALLL3 | | HNARSV | | D | | 00010 | 31 | 2 | 29L | 2431X1 | 1MCART | | |
| J0002 | | BLODR4 | J0003 | D | | 00010 | 31 | 10 | 10L | 4462Z0 | 1HJ1 | 1AMOTL | |
| J0003 | | HENGST | J0004 | D | | 00010 | 31 | 8 | 29L | 1431X1 | | | |
| J0004 | | DCRATI | J0005 | D | | 00010 | 31 | | | | | | |
| J0005 | | CALLS5 | J0006 | C | | 00010 | 31 | | | | | | |
| CALLS5 | | EDWNLD | CALLS8 | X | | 00010 | 31 | 16 | 10L | 4462Z0 | 1HJ1 | 1AMOTL | |
| J0006 | | CALLS6 | J0007 | C | | 00010 | 31 | | | | | | |
| CALLS6 | | EDWNLD | CALLS9 | X | | 00010 | 31 | | | | | | |
| J0007 | | CALLS7 | J0008 | C | | 00010 | 31 | | | | | | |
| CALLS7 | | BDEARM | CALLS1 | X | | 00010 | 31 | 8 | 10L | 4462Z0 | | | |

PUNCH CARD TRANSCRIPT

Figure 37. Example of Preflight to Postflight Main Network Coding on Extended Form 11.

(1)

INPUT No. 2

EXTENDED FORM 11

| Prior Node | ACT | WUC | Next Node | Node Type | PUT DECIMAL MSRF or Probability | NCLOK Clock No. | Release | Type Task | Priority | TIME (Tenths) | VAR | Dist. Type | N | DEC(1) OR AFSC/AGE | N | DEC(2) OR AFSC/AGE | N | DEC(3) OR AFSC/AGE | N | DEC(4) OR AFSC/AGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| J0008 | | JTAXI1 | J0009 | D | | 00010 | 3 | 1 | | 2 | 29L | | | | | | | | | |
| J0009 | | HEUNW1 | J0010 | D | | 00010 | 3 | 1 | | 1 | 29L | | | 2462R0 | | 3431E1 | | | | |
| J0010 | | SORTIE | J0011 | S | | 00010 | 1 | 1 | | | | | | | | | | | | |
| J0011 | | HEUNW2 | J0012 | D | | 00010 | 3 | 1 | | 1 | 29L | | | 2462R0 | | 1431E1 | | | | |
| J0012 | | JTAXI2 | J0013 | D | | 00010 | 3 | 1 | | 2 | 29L | | | 1431X1 | | 1421X3 | | 1D60 | | 1B4 |
| J0013 | | HRECOV | J0014 | D | | 00010 | 3 | 1 | | 1 | 29L | | | 1431X1 | | | | | | |
| J0014 | | GAS100 | J0015 | D | | 00010 | 3 | 1 | | 2 | 29L | | | 2431X1 | | | | | | |
| J0015 | | DCRMT2 | J0016 | D | | 00010 | 3 | 1 | | | | | | | | | | | | |
| J0016 | | DCRMT4 | J0017 | D | | 00010 | 3 | 1 | | | | | | | | | | | | |
| J0017 | | HFPST1 | | D | | 00010 | 3 | 1 | | 37 | 29L | | | 1431X1 | | 1D60 | | 1B4 | | |
| J0017 | | HCHPCK | | D | | 00010 | 3 | 1 | | 3 | 29L | | | 1432X0 | | | | | | |
| J0017 | | CALLS1 | J0018 | C | | 00010 | 3 | 1 | | | | | | | | | | | | |
| J0018 | | CALLS8 | J0019 | C | | 00010 | 3 | 1 | | | | | | | | | | | | |
| J0019 | | CALLS9 | | C | | 00010 | 3 | 1 | | | | | | | | | | | | |

PUNCH CARD TRANSCRIPT

Figure 37. Example of Preflight to Postflight Main Network Coding on Extended Form 11 (Concluded)

(2)

The example mission involves a bomb load (BLODR4) only (no gun or camera), and takes a 4-MAN load crew an hour using standard loading equipment. This time was computed by summing TACM 50-7 Standards for the particular ordinance load and adding fifteen (15) minutes for travel. The launch (engine start) task (HENGST) covers all elapsed time from the point the pilot joins the crew chief at the aircraft for walk around until the start of the taxi. It takes an average of .8 hours and includes time that the crew chief stands by while the pilot performs his checks and runs up the engine with the plane in chocks.

CONUS policies on download (BDWNLD) vary by base. Combat aircraft are never downloaded if at all possible. The only situation in which an aircraft must be downloaded are: An engine problem requiring runup in the test cell; a jacking problem involving more than one wheel; failure of weapons control/ release systems; work on the fuel cells, or if the aircraft must go into a hangar (PHASE). Of these, only engine problems and jacking have a fair likelihood of occuring as a ground abort (between engine start and takeoff). When a ground abort for engine or landing gear occurs, the download and upload are shown together in one task for networking convenience, even though the upload portion would occur much later. (This simplification should not make any significant difference in the simulation results). In most cases, ground abort will only require a dearm task (removing cartridge ejectors), and then a rearm and repeat of stray voltage checks when the maintenance is completed. Dearm and rearm are also networked in a single task (BDEARM). The call sections are checked in sequence (using "F" task stringing) and if there is no failure, the aircraft proceeds to taxi (JTAXI1). This taxi task consumes time, but no resources.

Three (3) 431R1 (four required in combat) are stationed at the end-of-runway (EOR) for final launch check (HRUNW1). One of these is a team chief who talks to the pilot via intercom. Two (2) munitions men (462RO) are also part of the launch EOR team to pull the pins on ordinance. All EOR crews are stationed there for a full eight (8) hour shift. EOR check is shown in the networks as a .1 hour task for two (2) 431X1s and two (2) 462ROs after a .2 hour taxi. A dedicated crew is not available for any other work and must be treated as a separate AFSC in LCOM. Runway checks are uniquely identified by an "R" in the fourth digit of their AFSC.

The sortie task (SORTIE) removes the aircraft from the simulation for a random time according to the sortie length distribution specified on the Form 20. The Extended Form 11 does not require any time or resource entry for a sortie task. Sortie tasks are coded with an "S" Selection Mode and there is only one sortie allowed per main network.

Two (2) 462RO munitions men are stationed at the other end of the runway to check returning aircraft for hung ordinance and to "safety" ordinance not dropped (task HRUNW2). One (1) 431R1 APG is also part of the recovery EOR team to park the aircraft for the ordinance EOR check. While the aircraft is taxiing in, the crew chief and an AGE handler are getting ready for recovery in the parking area. Their work is shown on the taxi task (JTAXI2). The crew chief then parks the aircraft in the .1 hour recovery task (HRECOV).

Aircraft are fueled in the parking area or revetment when the fuel truck arrives. The postflight is interrupted to allow two 431X1s and one POL driver to refuel the aircraft (GAS100). For the purpose of modeling, fueling is shown prior to postflight. This slight disparity with the actual time sequence makes no difference in the LCOM output since fuel trucks are not constrained. Fueling an empty A-7 requires .3 hours, and less time if the plane still has fuel aboard. In this example, the plane returns from air refueling with practically full tanks, so the task time is .2 hours by two (2) 431Xs. The Petroleum, Oil and Lube (POL) driver is not part of the maintenance unit for which manning is being determined, so he was not included in the model.

The aircraft is not to be turned for another mission and goes into a 3.7 hour end-of-day full postflight by the crew chief. End-of-day postflight on the A-7 includes an oil chip check (HCHPCK) requiring one (1) 432X0 for three (3) hours. Unscheduled maintenance is done in parallel with postflight (HFPST1) except for engine or autopilot work requiring engine runup and/or functional checkflight, and work requiring jacking the aircraft. These call sections are networked in sequence after CALLS1, unscheduled maintenance is completed. After all required network tasks are finished, the aircraft is released for another mission assignment (controlled by the Form 20s).

D. "QUICK TURN" NETWORKING EXAMPLE

If an aircraft is to fly again the same day, it is given a thruflight rather than a full end-of-day postflight. This is normally a requirement when modeling a surge scenario although it could be used in peacetime as well.

One way to adequately model this situation is to place all presortie tasks except for the engine start, taxi, and end-of-runway check, in configuration networks. This will allow use of a "cocked" aircraft resource, without repeating work already accomplished.

Figure 38 is an example of this modeling technique. Each mission will require a certain configuration class. (Refer to the section on Configuration Management in Chapter III, paragraph B). If the aircraft is not in the required configuration, it will be reconfigured by entering Node CN0001. A comprehensive aircraft check (PRPO) is required once every 24-hours; the "J" Selection Mode is used to represent this. The next tasks in line are servicing (SERVIC) and loading munitions (LOAD). These are performed each time this network is used.

The first node in the main network is the task for starting the engine (STENG). Modeling the main in this manner allows for any "cocked" aircraft to do the minimum tasks required to take-off. A Taxi (TAXI1) and an end-of-runway (EORCK) precede the actual sortie (SORTIE).

After the aircraft has flown, the unscheduled maintenance failure clocks are decremented (DCRMT1). It is assumed in this model that unscheduled maintenance is deferred until post sortie. This assumption would be derived from the operational scenario.

After the aircraft has landed, it can do one of two things. It can either immediately taxi (TAXI2), which it will do 96% percent of the time; or download any hung munitions and taxi (combined in the task, DWNLD), the remainder of the time. An abbreviated thruflight (POSFLT) is accomplished, the aircraft is parked (PARK) and then refueled (REFUEL). The maintenance call (CALLS1) is performed last. Please remember that this is an example only. To model real-life situation, other factors would need to be considered.

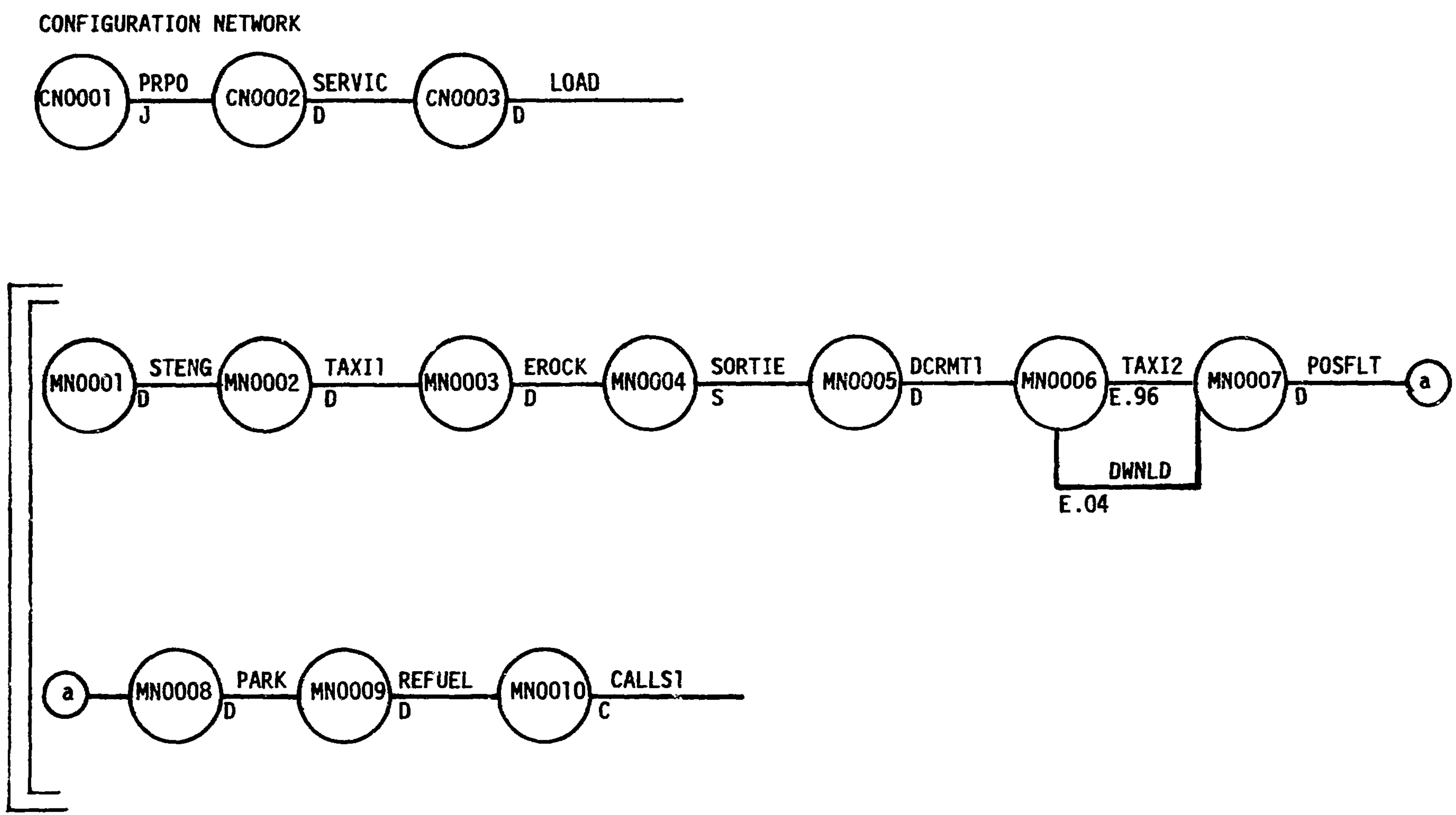



Figure 38. Example of Networking Quickturns for Surge Scenarios.

# SECTION VII

# CORRECTIVE MAINTENANCE TECHNIQUES

## A. CONTENT AND DATA SOURCES

The networks covering unscheduled corrective maintenance tasks are located by subsystem and broken up into call sections. Usually, they are called from the main network using the CALLS1 task (explained previously). Each network must start with a failure clock and parameter value of mean sorties between failure actions (MSBMA). This controls the frequency with which the network tasks will be processed. It must cover all the times a specialist is called to the aircraft in the field to fix an apparent problem, including cases where only some minor adjustment is required or the system checks out OK. This definition of maintenance frequency differs substantially from reliability measures of failure that consider only confirmed breakage under controlled conditions.

The networks also contain task times for work on aircraft and in field shops. Depot repair tasks are not handled by LCOM. They are incorporated in one task, PDEPOT, which takes care of the time that the part is out of the simulation.

The corrective maintenance networks represent the time a technician is tied up on the job and not available for other work. They must consider time to get to a job, time to fault isolate and check out the system, time to clean up, time to get parts, and standing time on multiple crew tasks. They are substantially different from the touch times developed in maintainability studies prepared by the contractor (LSAR). For example, a cockpit mounted radio that can be changed in a few minutes by removing six (6) screws might occupy a man for half an hour when total job time is considered.

The maintenance crew size shown for network tasks represents the number of people typically dispatched to the job. Crew size depends on safety factors, maintenance practice in the operating command to account for level of skill, the need for technical data while working, policy on checking work, accessibility of the item, and on-the-job training. More people will generally be dispatched than are indicated by a strictly touch-time task analysis.

Maintenance frequency task times, and crew sizes for new weapon systems, are developed by Air Force past experience on similar equipment, when possible. The Air Force Maintenance Data Collection (MDC) system is the basic information source on what it takes to maintain current equipment. Air Force engineers and experienced technicians must then evaluate differences and apply judgement factors to the MDC data in order to estimate task requirements for the new design. The development contractor is the primary source of design identification and engineering information.

## B. PROCEDURE

The first step is to define the proposed design of the new aircraft. Definition must be at least to subsystem level and preferably to line replaceable unit (LRU) level. The contractor's development proposal, submitted at the end of the validation phase, will usually encompass this level of design definition. Much useful information can be obtained through visits to the contractor's facility and thorough inspection of any mockups, prototypes, or test aircraft under construction. If there is a flying prototype, experienced Air Force technicians should be assigned to observe and evaluate maintenance procedures and requirements.

Given suitable design definition, the next step is to identify comparable systems and subsystems on existing aircraft. Comparability is assessed in terms of function, design concept, complexity, operating environment and maintainability features. The Air Force engineers assigned to the Systems Program Office (SPO) and their "Home Office" supporting cadre should conduct this analysis, and it should be coordinated by the program reliability/maintainability officer. It is essential that the analysis and rationale be completely documented and then kept current in each participating program office engineering group. A good working relationship between these people and the LCOM modelers should be cultivated.

The comparability analysis should be structured according to the contractor's preliminary work unit code manual at the subsequent level. The special criteria for identifying comparabilit must be defined for each subsystem at the outset. Experienced maintenance personnel in the program office and/or operating command should be brought in to familiarize each group of engineers with maintenance problems typically associated with their equipment, and jointly establish appropriate criteria. Getting both maintenance and engineering input is critical. For example, in one comparability study, airframe engineers initially based their criteria on the similarity of the heavy loadbearing structures to resist stress and fatigue cracking. The maintenance people pointed out the most day-to-day airframe repair work involves fitting skin panels, fitting access doors, and replacing fastners; not fixing broken wing struts. The kind of fastners, curvature, and stress on surfaces, and simple size of the aircraft, ay have more bearing than structural design on the comparability of flightline and field shop maintenance. However, vibration absorbing properties of the structure relate to the cause of skin maintenance and cannot be ignored either.

Once the criteria are established, the engineers compare the designs of similar aircraft; drawing on the experience of associates who have worked on various programs, contractor data, and Air Force technical orders, as necessary. The results are then written up by subsystem (3 digit) work unit code, to include: identification of comparable aircraft and subsystem work unit code(s); any additional LRUs in the new subsystem or LRUs by work unit code in the comparable system that are not applicable; any factors that should be applied to the comparable subsystem failure rates or task times in estimating for the new subsystem; and a narrative analysis specifying the criteria used and supporting rational for choosing the comparable subsystem and factors. Any scheduled maintenance considerations should be mentioned. In some cases, an item is so new or changed that there is nothing reasonably comparable. In that case, the best source of data (contractor, etc.) should be identified, and appropriate factors and degree of confidence discussed. Study results should be reviewed in conjunction with experienced maintenance personnel to be sure that no maintenance considerations were missed. The comparability study requires a considerable effort on the part of program office engineers, but has a payoff in their better understanding and heightened awareness of maintenance considerations, when they review contractor proposed designs and design change proposals.

The next step is to obtain MDC data tapes on aircraft with comparable subsystems, and process this information through a series of specially designed computer programs, the Common Data Extraction Programs (CDEP). These programs and processing instructions are in AFMSMMET Report 78-4. The program outputs are in a convenient format for use in developing a simulation data base. However, some base visits will be essential to verify and correctly interpret certain aspects of MDC coding for the comparable subsystems, and help identify certain requirements and procedures for using powered AGE.

The verified MDC data on the comparable systems, factored for identified design differences, is used to build an LCOM maintenance data base for the new aircraft. When this data base is completed, the networks, times, and particularly the crew sizes and AFSCs, should be reviewed with experienced Air Force maintenance personnel. (Operational command technicians on prototype, or test, aircraft make ideal reviewers.) This review is an interative process.

The basic procedure of design identification, comparability identification model construction with MDC data, and maintenance review is repeated on design changes to keep the data base current throughout the development and production phases. Test and operational evaluation data is considered as it becomes available. The operating command has a vested interest in the accuracy of the model as it will be eventually transferred to them.

(1) Network Structure

The basic task sequencing for a corrective maintenance network is shown in Figure 39. It must begin with an "F" task that identifies the failure clock. This serves as a gate controlling how often the subsequent network tasks are done. The gate is only opened and tasks processed when the clock on the "F" task indicates that an apparent failure has occurred. The "F" task is followed by the on-aircraft maintenance tasks needed to describe the corrective work, on Figure 39:

A task - to get and set up powered AGE.

X task - to gain access to the subsystem or LRU, particularly when done by a different AFSC than does the corrective action.

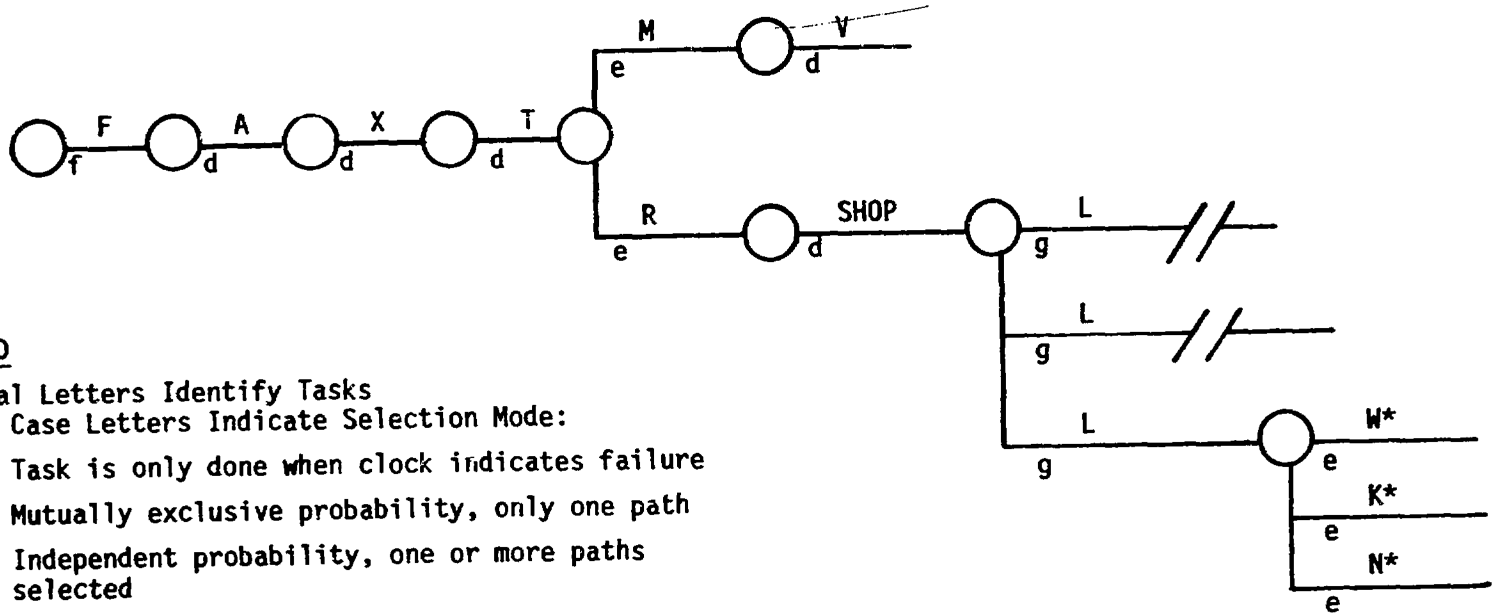
T task - to troubleshoot the system.

R task - to remove and replace an LRU.

M task - for any on-aircraft fix not involving LRU removal.

V task - to perform an inspection or functional check to verify that the subsystem has been fixed.

These tasks are coded with D, E, or A Selection Modes to describe the appropriate sequence of work at subsystem level. The "R" task is an average for all LRUs in the subsystem that are done by the same AFSC and crew size. If some items are removed by a different AFSC, these must be grouped into a parallel "R" task representing the set of LRUs removed by that AFSC and crew size. "E" Selection Mode probabilities determine which corrective task is processed.




**LEGEND**

Capital Letters Identify Tasks
Lower Case Letters Indicate Selection Mode:

f = Task is only done when clock indicates failure

e = Mutually exclusive probability, only one path

g = Independent probability, one or more paths selected

d = Task is always done

* = This any any subsequent work is on the LRU, and releases constraint on the next higher assembly

Figure 39. Schematic of Maintenance Network Basic Logic.

"R" tasks are normally followed by a shop entry task. These are dummy tasks because "E" and "G" selection logic cannot be run out of the same network node. It is followed by parallel "L" tasks representing failed LRUs. Six (6) selection mode probabilities determine which LRUs within the subsystem were removed. The following tasks are used to represent the possible shop actions on a removed LRU, in Figure 39:

W task - to bench check and repair the LRU.

K task - to bench check the LRU and find it serviceable.

N task - to bench check the LRU, find it NRTS, prepare it for shipment, and order a new one from Depot.

An asterisk can be placed in column 39 of the Extended Form 11 on a generate task to indicate that a shop task will not hold up the aircraft if a spare LRU is available. A "Q" task must be included with selection mode "D" and no asterisk in order to draw a spare LRU from supply. (An "I" mode can be used, instead of the "D", if cannibalization is desired.) The "N", "W", and "K" tasks must be coded with selection mode "E" to assure only one is processed to match each supply demand. The asterisk on the generate task tells the computer than an LRU is now being processed instead of an aircraft, and should be returned to supply when the task or task sequence is complete. It effectively separates the shop network from the aircraft network unless there was no spare to draw from supply.

(2) Coding Conventions

Node numbers for on-aircraft maintenance tasks are five (5) digits, right justified. The first three (3) digits correspond to the first three (3) digits of the subsystem work unit code, except that the first digit is entered as the corresponding alphabetic character. The last two (2) digits indicate the task sequencing. For example, for the 14A00 subsystem, node numbers would be A4A00, A4A01, A4A02, etc. For the 42C00 subsystem they would start with D2C00, D2C01, D2C02, etc.

The node following the shop dummy task and preceding the "L" task is six (6) digits, with an "S" in the first position, followed by the subsystem work unit code. Subsequent nodes for shop tasks are also six digits, with "I" in the first position, the first four (4) digits of the LRU work unit code, and the last position used for task sequencing as described above. For example, the prior node to the "L" task in the 14A00 network would be coded SA4A00, and the next node might be IA4AA0. These node numbering conventions may seem a bit confusing at first, but they are quickly mastered, and if followed help prevent serious node duplication errors when networks are modified and updated later.

In order to accurately use the Parts Post Processor, task Types "4", "6", and "7" should be used. While use of these three (3) task types is required to use this post processor it is not necessary to change old data bases if it is not going to be used. The Main Module will run properly, but not produce the proper post processor data records. However, Type 4 tasks should always be used to ensure that depot/NRTS statistics are correct. Figure 40 illustrates their use.

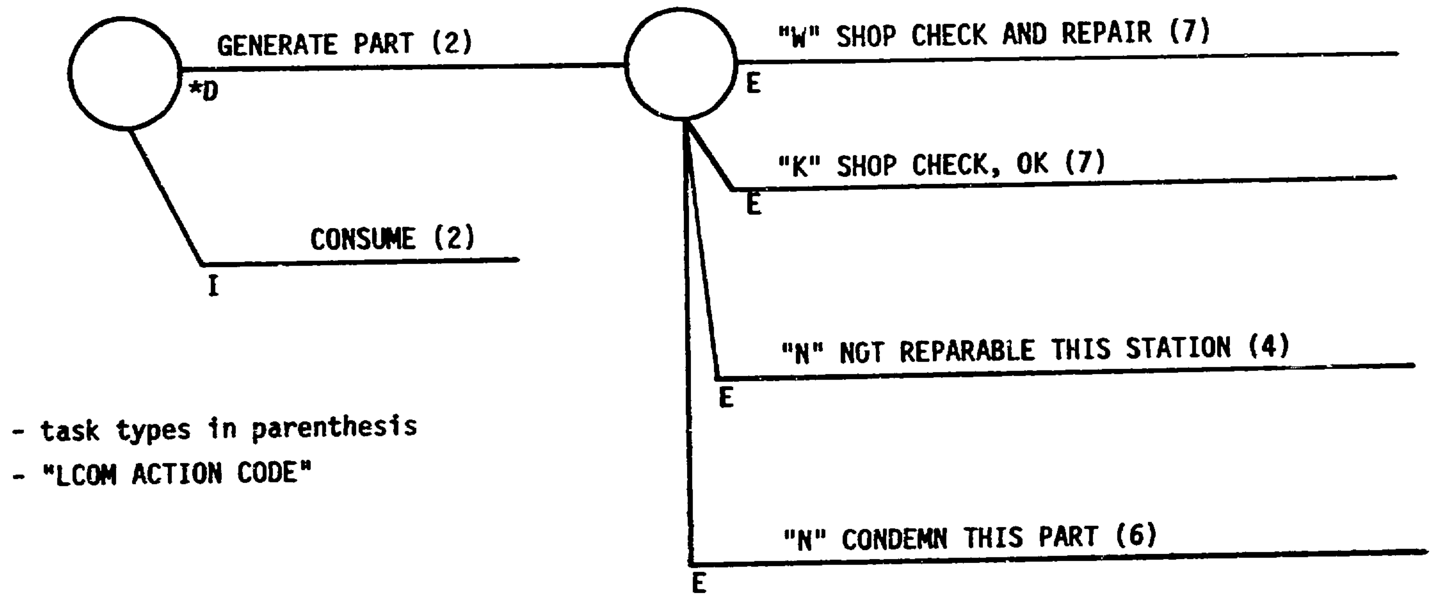



Figure 40. Example of Type 4, 6, 7 Tasks.

C. USING THE MDC DATA BASE

Use of the Common Data Extraction Programs (CDEP) is documented in AFMSMMET Report 78-4, and several specific programs have been written to manipulate this data. A description of the data base is contained in the appropriate users documentation and will not be repeated here.

(1) Computations with MSBMA

The MSBMA clock value may have to be recomputed or adjusted in the course of coding a network. Since it is an inverse number, the correct computations are not always intuitively obvious. The relationship of MSBMA to the probability of a maintenance action on the subsystem is:

$$P_M = \frac{1}{(MSBMA}$$

To combine two MSBMA values, interactions can usually be ignored and their probabilities added:

$$\frac{1}{MSBMA_{TOTAL}} = \frac{1}{MSBMA_1} + \frac{1}{MSBMA_2}$$

or:

$$MSBMA_{TOTAL} = \frac{1}{\frac{1}{(MSBMA_1} + \frac{1}{MSBMA_2)}}$$

For example, if an LRU with an MSBMA of every 50 sorties is included in a subsystem with a clock of 100, the new clock value is:

$$MSBMA = \frac{1}{\frac{(1}{(50} + \frac{1)}{100)}} = \frac{100}{3} = 33$$

The new clock value is not the average of the two MSBMA values, but is a number lower than either of them. This makes sense when one realizes that if another source of failure is added to a subsystem that is already failing every 50 sorties, it is going to fail more often. More frequent failures mean a lower value of MSBMA.

The relative significance of MSBMA values is also deceiving. Large differences in large MSBMA numbers are often insignificant, while even relatively small differences in small MSBMA values represent important differences. Consider MSBMA values of 2000 and 1000. The difference in terms of probability of a maintenance action is:

$$P\ Diff. = \frac{1}{1000} - \frac{1}{2000} = \frac{1}{2000} = .0005.$$

On the other hand, the difference between MSBMA values of 10 and 5 is:

$$P\ Diff. = \frac{1}{5} \quad \frac{1}{10} \qquad \frac{1}{10} = .1000$$

The latter difference is 200 times greater in terms of frequency of failure. For this reason, subsystems which fail less than once in 2000 sorties can often be ignored in building networks, but changes and modifications which affect low MSBMA numbers may have considerable impact on the simulation results.

When the aircraft being modeled has more than one of a given subsystem installed, the unit MSBMA taken from CDEP must be divided by the number installed to get the correct total maintenance rate. For example, if an aircraft has two (2) identical hydraulic pumps with the same work unit code identification, and the data bank shows that a single pump requires maintenance every fifty (50) sorties, than the average MSBMA rate for the two pumps will be once every twenty-five (25) sorties.

If the comparability study indicates a 25% percent improvement in reliability for a new subsystem, it will only fail .75 times as often. The data bank MSBMA for comparable unit must be divided by .75 to get the larger MSBMA for the new subsystem.

(2) Network with Expendable LRU's

The remainder of this section gives examples of some more complex networking problems.

There are many throwaway electrical items coded as on-aircraft remove/replace jobs in MDC reporting which never go into the shop. These include such items as relay switches, and circuit breakers throughout the aircraft. The shop data bank printout gives the counts of items reported removed and reported in shop, and also shows a "G" probability of no shop. However, differences in these reported actions do not necessarily mean throwaways. They could be due to bad reporting or have another explanation. LRUs should not be networked as expendable unless it has been confirmed with maintenance technicians in the field.

(3) Engine Network

MDC data is of relative little value in developing a network for a basic engine. Data bank printouts are available to show engine work on aircraft, work on entire engines in the engine shop, shop work on components removed from the engine, special inspections, and removals for access. However, so much of the unscheduled maintenance is reported against 04 (inspection) codes and even 09 (shop general) codes, that the data bank probabilities often are not meaningful.

It may not be feasible to determine the frequency of engine removals from MDC Data since there is no standard way of reporting an engine removal for failure. For example, on the A-7D work unit codes 23B, 23AJ, and removal for access (to the internal parts) are variously used. The AFLC depot engine managers require separate reporting of each engine removal for cause, and these are listed in the monthly base K-18 maintenance summary. The average K-18 count over the past year, from bases of interest, may be the best estimate of mean removal rates for a comparable engine.

The engine removal task sequence through functional check flight, and the proportion of on-aircraft troubleshoot-adjust-fix to removal, should be based on information obtained from the engine shops maintaining comparable engines, and modified for the maintenance concept and requirements of the new engine.

An example of engine network is shown in Figure 41. When an engine is changed, the aircraft is towed to the test cell for trim and runup, and then taken up for a functional check flight. The engine goes into the shop for teardown. Portions of the engine may be removed and replaced, and the engine reassembled for use as a spare on the next aircraft requiring an engine change. The parts that were removed from the engine are processed through the field shops; and when repaired, are returned to stock.

Engine network coding is shown in Figure 42. The example only depicts one of the engine sections in the shop to illustrate the technique. The first asterisk is on the engine teardown task. This tells the computer it is now working on an engine (WUC 23000) and no longer holds up the aircraft. A "Q" task draws the replacement engine from spare stock if available. At the next stage the "Q" task draws an assembly to be replaced on the engine. The asterisk at this level tells the computer that the work is on the removed assembly and does not hold up the engine.

The engine work center may be subdivided into different sections which do not do each other's work. This is one of the maintenance concept assumptions that must be obtained from the operating command. In Figure 42, the flightline dispatch crew is coded 432XO, technicians assigned exclusively to shop work are coded 43250, and the crew dedicated to the test cell is coded 432TO. The pilot who does the functional check flight is coded 1115K. He is treated as a dedicated resource and is normally only available during daylight shifts. The functional check flight is coded as a maintenance task rather than as a sortie task because it is not scheduled on a Form 20. Note the use of header cards to supply nomenclature for the string of check tasks following engine change or on-aircraft fix. Also note that resources are not shown for these tasks when they are repeated.

Engine accessories and accessory systems removed and replaced on aircraft are shown in separate networks (engine fuel system, engine electrical system, engine oil system, etc.). These networks can be satisfactorily modeled from MDC data and were not illustrated for this example.

(4) Complex Avionics Networks

The A-7D forward looking radar (WUC 73A00) is one of several integrated subsystems comprising the A-7D bombing avionics. It is one of the most complex networking problems a model builder is likely to encounter. Some of the troubleshooting and radar boresighting are reported under 04 series work unit codes. Much of the troubleshooting is reported as can-not-duplicate (CND). If the initial troubleshoot does not locate the fault, another specialist will be called in to check his subsystem, until the problem is found or clearly cannot be duplicated. Some corrective actions require multiple removals for access, and some access removals are checked in the shop. When NRTS items return from depot they are given a full bench check, and in some cases may be NRTS back again.

These networks are diagramed in Figure 43 and the coding is shown in

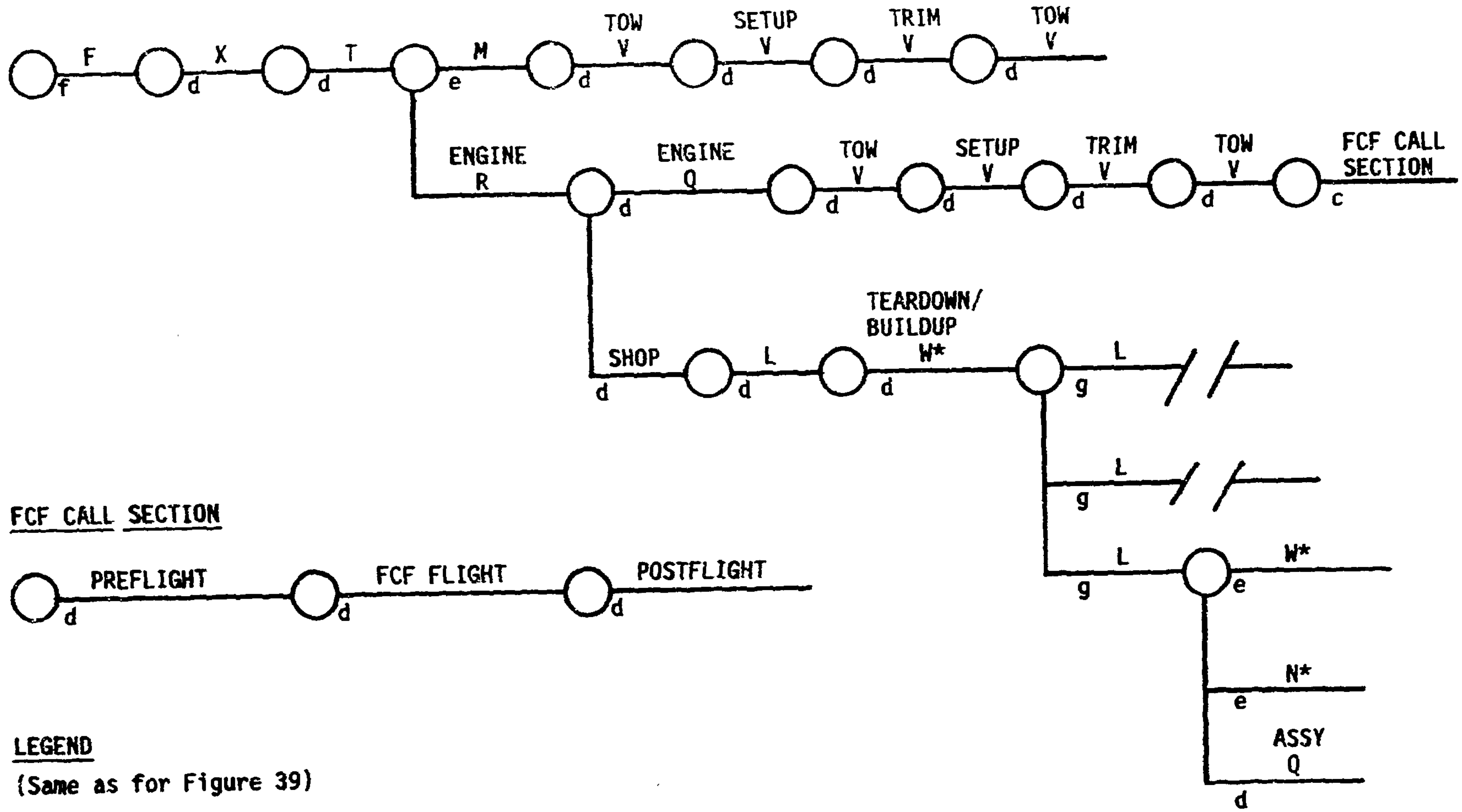



Figure 41. Schematic of Engine Network

INPUT No. 2

EXTENDED FORM 11

| Prior Node | ACT | WUC | Next Node | HPNTR | Sol. Mode | PUT DECIMAL MSSF or Probability | MCLOX Clock No. | Release | Type Task | Priority | TIME (Tenths) | VAR | Dist. Type | N | DEC(1) OR AFSC/AGE | N | DEC(2) OR AFSC/AGE | N | DEC(3) OR AFSC/AGE | N | DEC(4) OR AFSC/AGE | Continuation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | H | | | 23B00 | | | | BASIC ENGINE | | | | | | | | | | | |
| B3B00 | | F23B00 | B3B01 | | F | .28 | 23B00 | | Z1 | | | | | | | | | | | | | |
| B3B01 | | X23B00 | B3B02 | | D | | 23B00 | | Z1 | | 60 | Z9L | | | 3431X1 | | | | | | | |
| B3B02 | | T23B00 | B3B03 | | D | | 23B00 | | Z1 | | 24 | Z9L | | | 3432X0 | | | | | | | |
| B3B03 | | A23B00 | B3B04 | | E | .90 | 23B00 | | Z1 | | 13 | Z9L | | | 2432X0 | | | | | | | |
| | | | | H | | | 23B00 | | | | TOW AIRCRAFT, PUT IN CELL | | | | | | | | | | | |
| B3B04 | | V23B00 | B3B05 | | D | | 23B00 | | Z1 | | 07 | Z9L | | | 1TUG | | | | | | | |
| | | | | H | | | 23B00 | | | | RUN UP AND TRIM | | | | | | | | | | | |
| B3B05 | | V23B01 | B3B06 | | D | | 23B00 | | Z1 | | 02 | Z9L | | | 6431X1 | | | | | | | |
| B3B06 | | V23B02 | B3B07 | | D | | 23B00 | | Z1 | | 25 | Z9L | | | 343270 | | 2431X1 | | | | | |
| | | | | H | | | 23B00 | | | | TOW AIRCRAFT BACK | | | | | | | | | | | |
| B3B07 | | V23B03 | | | D | | 23B00 | | Z1 | | 09 | Z9L | | | 5431X1 | | 1TUG | | | | | |
| | | | | H | | | 23B00 | | | | ENGINE CHANGE, RUNUP, TRIM | | | | | | | | | | | |
| B3B03 | | A23B00 | B3B08 | | E | .10 | 23B00 | | Z1 | | 4E | Z9L | | | 4432X0 | | | | | | | |

PUNCH CARD TRANSCRIPT

Figure 42. Engine Network Coding.

(1)

INPUT No. 2

EXTENDED FORM 11

| Prior Node | ACT | WUC | Next Node | Sel. Mode | PUT DECIMAL MSBF or Probability | MCLOX Clock No. | Release | Type Task | Priority | TIME (Tenths) | VAR | Dist. Type | N | DEC(1) OR AFSC/AGE | N | DEC(2) OR AFSC/AGE | N | DEC(3) OR AFSC/AGE | N | DEC(4) OR AFSC/AGE | Continuation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B3B08 | Q | 23B00 | B3B09 | D | | Z3B00 | | 2 | 1 | | | | | | | | | | | | |
| B3B09 | V | 23B00 | B3B10 | D | | Z3B00 | | 2 | 1 | | | | | | | | | | | | |
| B3B10 | V | 23B01 | B3B11 | D | | Z3B00 | | 2 | 1 | | | | | | | | | | | | |
| B3B11 | V | 23B02 | B3B12 | D | | Z3B00 | | 2 | 1 | | | | | | | | | | | | |
| B3B12 | V | 23B03 | B3B13 | D | | Z3B00 | | 2 | 1 | | | | | | | | | | | | |
| | | | | H | | Z3B00 | | | | FUNCTIONAL CHECK FLIGHT | | | | | | | | | | | |
| B3B13 | C | ALLS7 | B3B14 | C | | Z3B00 | | 2 | 1 | | | | | | | | | | | | |
| CALLS7 | V | PRFLT | B3B15 | D | | Z3B00 | | 2 | 1 | 18 | 29 | L | 2 | 431X1 | 1 | DG0 | 1 | B4 | | | |
| B3B15 | V | FCF00 | B3B16 | D | | Z3B00 | | 2 | 1 | 10 | 29 | L | 1 | 1115K | 2 | 431X1 | | | | | |
| B3B16 | V | PSTFL | | D | | Z3B00 | | 2 | 1 | 25 | 29 | L | 2 | 431X1 | 1 | DG0 | 1 | B4 | | | |
| B3B14 | S | HOP | SB3B00 | D | | Z3B00 | | 2 | 1 | | | | | | | | | | | | |
| | | 23B00 | | H | | Z3B00 | | | | ENGINE TEARDOWN, BUILDUP | | | | | | | | | | | |
| SB3B00 | L | 23B00 | IB3B00 | D | | Z3B00 | | 2 | 3 | | | | | | | | | | | | |
| IB3B00 | W | 23B00 | IB3B01 | D | | Z3B00 | * | 2 | 3 | 80 | 29 | L | 2 | 43250 | | | | | | | |

PUNCH CARD TRANSCRIPT

Figure 42. Engine Network Coding (Cont'd)

(2)

INPUT No. 2

EXTENDED FORM 11

| Prior Node | ACT | WUC | Next Node | Sel. Mode | PUT DECIMAL MSBF or Probability | MCLOK Clock No. | Release | Type Task | TIME (Tenths) | VAR | Dist. Type | N | DEC(1) OR AFSC/AGE | N | DEC(2) OR AFSC/AGE | N | DEC(3) OR AFSC/AGE | N | DEC(4) OR AFSC/AGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 23BA0 | | H | | 23B00 | | | BASIC | ENGINE | | | ASSEMBLY | | | | | | |
| IB3B01 | L | 23BA0 | IB3BA0 | D | | 23B00 | | 23 | | | | | | | | | | | |
| IB3BA0 | N | 23BA0 | | D | | 23B00* | | 23 | 18 | 29 | L | | 1532X0 | | | | | | |
| IB3BA0 | D | 23BA0 | | D | | 23B00 | | 23 | | | | | | | | | | | |

PUNCH CARD TRANSCRIPT

Figure 42. Engine Network Coding (Conclude.)

(3)

Figure 44. It is important that prior CNDs be shown in the networks containing the eventual corrective action so that the simulation clocks and frequencies of dispatch are not distorted.

Access problems are peculiar to each design and usually cannot be extrapolated from data on another aircraft. However, this example of an A-7D access problem is shown to illustrate the impact a poor design can have, and emphasize the importance of a thorough review of mockups, prototypes, and test aircraft to highlight and correct any such condition.

The FLR Air Navigation Multiple Indicator, WUC 73AE0, is mounted in the cockpit. There is no difficulty in removing and replacing this indicator, however, there is a small plug behind it that sometimes needs replacement. It does not even have a work unit code. This plug can only be reached if the windshield is removed. Changing windshields is an 11-hour job by three (3) 431C1, Aero Repair Specialists. Before they can do it though, two (2) 322X1s must remove the HUD and two (2) 328X3s must remove the RHAW indicator. After the multiple indicator and plug are changed and all the rest put back together, the 422X1s must do a cabin pressure check. This requires 322X1s to swing out the forward looking radar system so that pressure lines can be hooked up through the nose. After everything is connected, there is a 24-hour cure time for the test. Because of poor access, the failure of one small plug can tie down an aircraft for about two days.

Only two (2) of the nine (9) FLR LRUs are illustrated in Figure 44. The shop entry for the indicator coming off the long access goes directly to the appropriate shop tasks, bypassing the "G" probability. The NRTS (NMCS) task is followed by a depot turnaround time dummy, PDEPOT. The time for this task is set on the PHASE program SPEC card and no Extended Form 11 entry is required. A task is shown for bench check on return from depot. This task does not appear in MDC data runs. A maintenance concept assumption from the operating command and/or the opinion of experienced technicians should be sought to determine whether such checks should be in the data base for a new aircraft.

One more unusual network feature is shown in Figure 44. When the mount breaks or is damaged, the radar set has to be realigned by dry boresighting. This is a six-hour job. It is shown in parallel to the "Q" task following the "G" probability that determines whether the mount has to be changed.

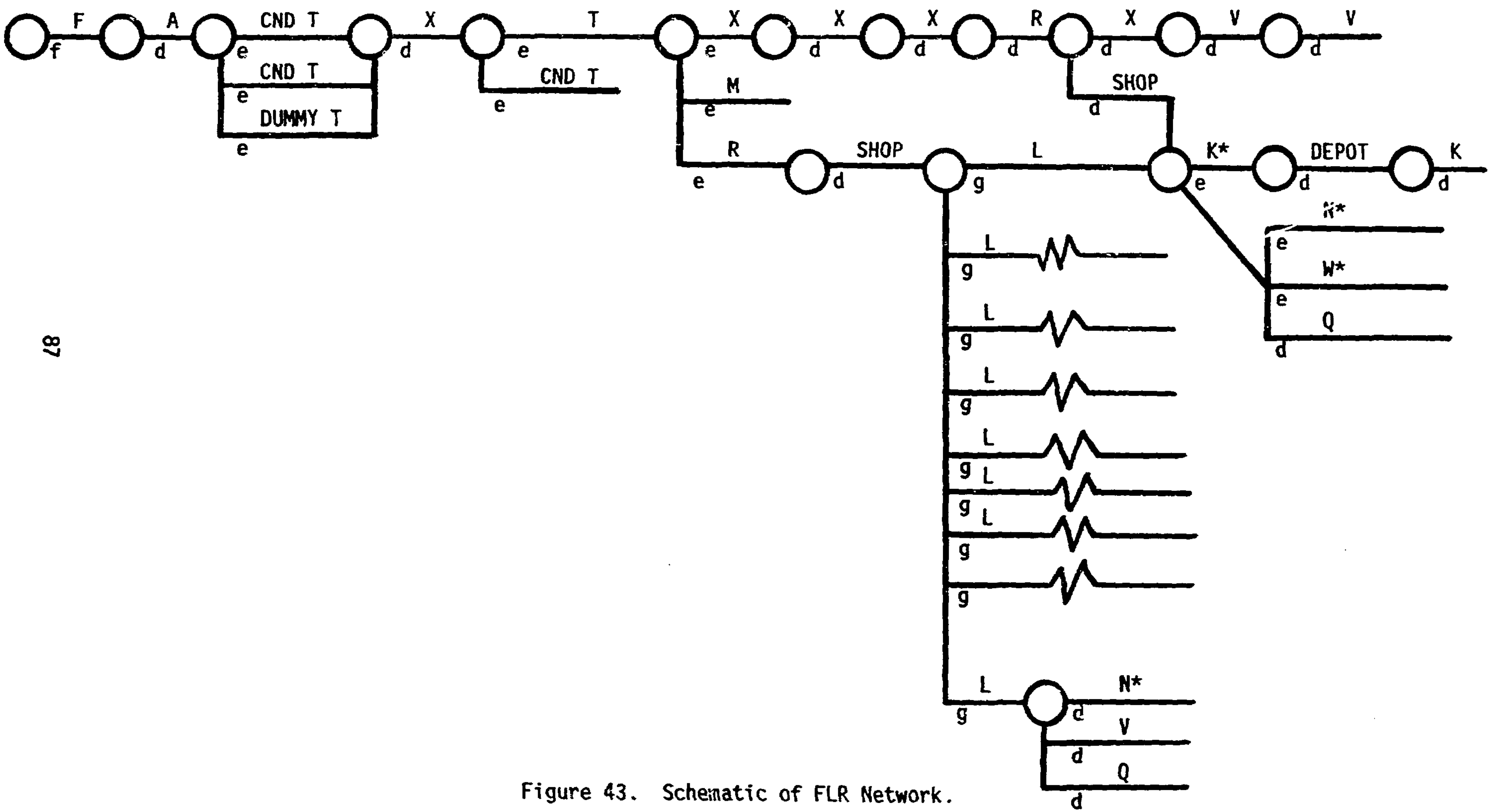



Figure 43. Schematic of FLR Network.

INPUT No. 2

EXTENDED FORM 11

| Prior Node | WUC | Next Node | | Sol. Mode / PUT DECIMAL MSBF or Probability | MCLOK Clock No. | Type Task | TIME (Tenths) | VAR | DEC(1) OR AFSC/AGE | DEC(2) OR AFSC/AGE | DEC(3) OR AFSC/AGE | DEC(4) OR AFSC/AGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | H | | 75A00 | FORWARD LOOK RADAR APG126 | | | | | | |
| G3A00 | F73A00 | G3A01 | | F9.0 | 73A00 | 21 | | | | | | |
| G3A01 | A73A00 | G3A02 | | D | 73A00 | 21 | 02 | 29L | 1421X3 | 1060 | 1431X1 | |
| G3A02 | T73001 | G3A03 | | E.09 | 73A00 | 21 | 13 | 29L | 2322X1 | 1060 | | |
| G3A02 | T73004 | G3A03 | | E.04 | 73A00 | 21 | 13 | 29L | 2328X4 | 1D60 | | |
| G3A02 | T73000 | G3A03 | | E.87 | 73A00 | 21 | | | | | | |
| G3A03 | X73A00 | G3A04 | | D | 73A00 | 21 | 05 | 29L | 1431X1 | | | |
| G3A04 | T73A00 | G3A05 | | E.92 | 73A00 | 21 | 10 | 29L | 2322X1 | 1060 | | |
| G3A04 | T73A0C | | | E.08 | 73A00 | 21 | 13 | 29L | 2322X1 | 1060 | | |
| G3A05 | R73A00 | G3A06 | | E.71 | 73A00 | 21 | 19 | 29L | 2322X1 | 1060 | | |
| G3A06 | M73A0b | | | E.27 | 73A00 | 21 | 9 | 29L | 2322X1 | 1060 | | |
| G3A06 | SHOP | SG3A00 | | D | 73A00 | 21 | | | | | | |
| | 73AE9 | | H | | 73A00 | AC RAVL 11AC, 73EA, 76FF, PC | | | | | | |
| G3A05 | X73AE1 | G3A07 | | E.02 | 73A00 | 21 | 17 | 29L | 2322X1 | | | |

PUNCH CARD TRANSCRIPT

Figure 44. Integrated Avionics FLR Subsystem Network.

(1)

INPUT No. 2

EXTENDED FORM 11

| Prior Node | ACT | WUC | Next Node | Header | Sel. Mode | PUT DECIMAL MSBF or Probability | NCLOK Clock No. | Release | Type Task | Priority | TIME (Tenths) | VAR | Dist. Type | N | DEC(1) OR AFSC/AGE | N | DEC(2) OR AFSC/AGE | N | DEC(3) OR AFSC/AGE | N | DEC(4) OR AFSC/AGE | Continuation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G3A07 | X | 73AE2 | G3A08 | | D | | 73A00 | | 2 | 1 | 110 | 29 | L | | 3431C/ | | | | | | | |
| G3A08 | X | 73AE3 | G3A09 | | D | | 73A00 | | 2 | 1 | 17 | 29 | L | | 2328X3 | | | | | | | |
| G3A09 | R | 73AE0 | G3A10 | | D | | 73A00 | | 2 | 1 | 13 | 29 | L | | 2322X/ | | | | | | | |
| G3A10 | S | HOP | IG3AE0 | | D | | 73A00 | | 2 | 1 | | | | | | | | | | | | |
| G3A10 | X | 73AE4 | G3A11 | | D | | 73A00 | | 2 | 1 | 18 | 29 | L | | 2322X/ | | | | | | | |
| G3A11 | V | PKEK1 | G3A12 | | D | | 73A00 | | 2 | 1 | 36 | 29 | L | | 2422X/ | | | | | | | |
| G3A12 | V | PCES2 | | | D | | 73A00 | | 2 | 1 | 240 | CC | | | | | | | | | | |
| | | 73AE0 | | H | | | 73A00 | | | | AIR NAV MULT INDICATOR | | | | | | | | | | | |
| SG3A00 | L | 73AE0 | IG3AE0 | | G | .02204 | 73A00 | | 2 | 3 | | | | | | | | | | | | |
| IG3AE0 | W | 73AE0 | | | E | .86 | 73A00 | * | 2 | 3 | 46 | 29 | L | | 2322X/ | | | | | | | |
| IG3AE0 | K | 73AE0 | | | E | .10 | 73A00 | * | 2 | 3 | 14 | 29 | L | | 2322X/ | | | | | | | |
| IG3AE0 | W | 73AE0 | IG3AE1 | | E | .04 | 73A00 | * | 2 | 3 | 21 | 29 | L | | 2322X/ | | | | | | | |
| IG3AE1 | P | DEPOT | IG3AE2 | | D | | 73A00 | | 2 | 3 | | | | | | | | | | | | |
| IG3AE2 | K | 73AE1 | | | D | | 73A00 | | 2 | 3 | 14 | 29 | L | | 2322X/ | | | | | | | |

AF 1520

PUNCH CARD TRANSCRIPT

Figure 44. Integrated Avionics FLR Subsystem Network (Cont'd)

(2)

INPUT No. 2
EXTENDED FORM 11

| Prior Node | ACT | WUC | Next Node | HEADER | Sel. Mode | PUT DECIMAL MSBF or Probability | NCLOX Clock No. | Release | Type Task | Priority | TIME (Tenths) | VAR | Disc. Type | TIME UNIT | N | DEC(1) OR AFSC/AGE | N | DEC(2) OR AFSC/AGE | N | DEC(3) OR AFSC/AGE | N | DEC(4) OR AFSC/AGE | Continuation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| IG3AE0 | Q | 73AE0 | | | D | | 73A00 | | 21 | | | | | | | | | | | | | | |
| | | 73AJ0 | | H | | | 73A00 | | | | RADAR SET MOUNT | | | | | | | | | | | | |
| SG3A00 | L | 73AJ0 | IG3AJ0 | | D | | 73A00 | | 23 | | | | | | | | | | | | | | |
| IG3A00 | N | 73AJ0 | | | D | | 73A00 | | 23 | | 10 | 29L | | | | 1322K1 | | | | | | | |
| IG3A00 | Q | 73AJ0 | | | D | | 73A00 | | 21 | | | | | | | | | | | | | | |
| IG3A00 | V | 73AJ0 | | | D | | 73A00 | | 21 | | 60 | 29L | | | | 2322K1 | | | | | | | |

PUNCH CARD TRANSCRIPT

Figure 44. Integrated Avionics FLR Subsystem Network (Concluded)

(3)

## SECTION VIII

## NETWORKS FOR PHASED AND PERIODIC SCHEDULED MAINTENANCE

### A. PHASE INSPECTIONS

The number and frequency of phases is a pokicy assumption to be provided by the operating command. Networks for phased inspection work are based on phase procedures for similar aircraft under a similar inspection concept and must be developed through interview with wxperienced technicians in the field. The inspection work cards are too detailed to network directly and MDC reporting is far too gross. The work done in each phase and the task sequences, times and crew sizes for each AFSC who has a scheduled task, must be set out in network form. A linear series of work card tasks by the same crew should be networked as a single task. The simplest phase network would show each specialists crew's work as one task and all these tasks would be shown in parallel. It is not usually so simple since there may be constraints and access requirements among the work by various specialists that must be identified and shown in the network. Any scheduled removals which go to the shop for servicing must also be shown. For example, hydraulic filters are regularly replaced and sent to the shop for cleaning, generating a task workload in the hydraulics shop.

The phase tasks for comparable systems must be carefully reviewed in terms of the new aircraft design and maintenance concepts in order to delete inappropriate tasks, modify others, and add any new tasks. Contractor recommendations, engineering evaluations, opinions of experienced maintenance personnel, and operating command policy assumptions, need to be sought and considered in making these judgements.

Unscheduled corrective maintenance in phase may be estimated from MDC data on similar systems and subsystems. It can be networked as an activity, using the Form 20s, or as a CALL section, using failure clocks.

### B. OTHER SCHEDULED INSPECTIONS AND TIME CHANGE ITEMS

The lists of 04 inspections in the work unit code manuals, the data bank runs on these inspections, and the data bank runs for scheduled removals, should be carefully reviewed for all comparable aircraft. A list of inspections and time changes applicable to the new aircraft must be developed, using this data as a starting point, but adjusting for differences in design and maintenance concepts. Contractor recommendations can be helpful if available, but should be verified by Air Force engineers and technicians.

Inspections that occur at calendar intervals may be scheduled on the Form 20s. Examples are the 45-day corrosion wash for fighter aircraft, or the annual teardown and inspection of the M-61 gatling gun on the A-7D. Only major inspections that tie up the aircraft for half a day or more should be handled this way. The network should not include a failure clock. It is entered through a dummy mission in the main network.

There are many other scheduled inspections that are done in conjunction with postflight when they come due. This method is cumbersome, except where the inspection is done only after completing certain types of missions. The more general way is to use scheduled inspection networks with failure clocks based on the inspection interval. These clocks are only decremented and interrogated on missions going to postflight. Coding conventions are similar to unscheduled maintenance networks except that the task type is three (3), the work unit codes and clocks have an "S" in the last position, and the nodes are six (6) digits, starting with "X". These conventions avoid any unintended duplication of nodes or tasks used in unscheduled maintenance. Two example networks from an A-7D model are shown coded in Figure 45.

Every fifty (5) flight hours, the water collection bag on the air conditioner must be emptied. This is done in 100-hour Phase and during a postflight, half-way between Phases. The 433X1 technician must remove the water separator (41AAL) to do this. The whole job is generally coded in MDC as a removal for access. The postflight check is shown in the network as a scheduled check every thirty-six (36) postflights (100 flying hours at a 1.8 sortie length and 50% percent average successful aircraft turnaround).

The cabin pressure regulator (41BCA) and pressure valve (41BCC) are replaced every four (4) years (every 550 sorties at peacetime flying rates). The job requires radar swing-out by AFSC 32221, access removal of armor plate (11AAL) by a 431X1 crew chief, and a pressure check after the components are replaced.

The postflight clock values on scheduled tasks must be adjusted when scenario assumptions are changed.

INPUT No. 2

EXTENDED FORM 11

| Prior Node | ACI | WUC | Next Node | Sel. Mode | PUT DECIMAL MSBF or Probability | NCLOK Clock No. | Release | Type Task | Priority | TIME (Tenths) | VAR | Dist. Type | N | DEC(1) OR AFSC/AGE | N | DEC(2) OR AFSC/AGE | N | DEC(3) OR AFSC/AGE | N | DEC(4) OR AFSC/AGE | Continuation |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | H | | 41AAS | | | | AIR COND WATER COLL CHECK | | | | | | | | | | | |
| XD1AA0 | | F41AAS | XD1AA1 | | F36.0 | 41AAS | | 3 | 1 | | | | | | | | | | | | |
| XD1AA1 | | V41AAS | | D | | 41AAS | | 3 | 1 | 27 | 29L | | | 2422X1 | | | | | | | |
| | | | | H | | 41BCS | | | | CABIN PRESS REG, VALVE TC | | | | | | | | | | | |
| XD1BC0 | | F41BCS | XD1BC1 | | F550.0 | 41BCS | | 3 | 1 | | | | | | | | | | | | |
| XD1BC1 | | X41B1S | XD1BC2 | D | | 41BCS | | 3 | 1 | 7 | 29L | | | 2431X1 | | | | | | | |
| XD1BC2 | | X41B2S | XD1BC3 | D | | 41BCS | | 3 | 1 | 18 | 29L | | | 2322X1 | | | | | | | |
| XD1BC3 | | R41BCS | XD1BC4 | D | | 41BCS | | 3 | 1 | 25 | 29L | | | 2422X1 | | | | | | | |
| XD1BC4 | | V41B1S | XD1BC5 | D | | 41BCS | | 3 | 1 | 30 | 29L | | | 2422X1 | | | | | | | |
| XD1BC5 | | V41B2S | | D | | 41BCS | | 3 | 1 | 240 | 0 | C | | | | | | | | | |

AF FORM 1530

PUNCH CARD TRANSCRIPT

Figure 45. Scheduled Maintenance Example.

## APPENDIX

The Appendix consists of Headquarters Air Force Systems Command/SDD letter, Subject: "Use of Logistics Composite Model Data in Secretary of Air Force Program Reviews", with two attachments (1) System Readiness - Sustainability Chart and (2) Major Aircraft Program Offices, 24 September 1980, Headquarters Aeronautical Systems Division (AFSC)/EN letter, Subject: "Use of Logistics Composite Model Data in Secretary of the Air Force Program Reviews (Your Ltr, 24 Sep 80)," 14 October 1980 and Headquarters Air Force Systems Command/SDD letter, Subject: "Use of Logistics Composite Model (LCOM) Data for Use in Secretary of the Air Force Program Review (SPR) Sustainability Chart," with four attachments (1) Distribution List, (2) Attendance List, (3) Draft Sustainability Chart and Instructions, (4) Problem Areas/Considerations in Applying LCOM in Generating an SPR Sustainability Chart, 8 December 1980

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE SYSTEMS COMMAND
ANDREWS AIR FORCE BASE, DC 20334

24 SEP 1980

REPLY TO ATTN OF: SDD

SUBJECT: Use of Logistics Composite Model Data in Secretary of Air Force Program Reviews

TO: HQ ASD/EN

1. HQ AFSC is proposing System Readiness information be included in the Secretary of the Air Force Program Reviews (SPRs). To that end, we have been working with your Modeling and Analysis Branch in developing a format for showing the ability of aircraft weapon systems to sustain wartime operations. The attached chart, "System Readiness - Sustainability," is an example of the type of data we expect to see in the SPR. The program office will be responsible for presenting this chart and the Logistics Composite Model (LCOM) would be the source of the "actual capability" information. The ASD LCOM group would be tasked by the program office to provide support.

2. The specific purpose of the chart is to convey the wartime requirement as specified in the USAF War Mobilization Plan (WMP) and the actual capability that can be supported with existing levels (or planned levels for systems not yet deployed) of manpower, spares, and support equipment for a given scenario and system reliability. From our discussions with Capt Radcliff, ASD/ENESA, it appears the aircraft LCOM data on file would require updating and each model would need to be tailored to support our needs. There is no question that the LCOM can be used to generate the data we need for a sustainability chart.

3. We have presented this concept to AFSC/CC/SD, AFLC/CC, HQ USAF/LE, and HQ TAC/CV with very favorable support. However, before we present our proposal for System Readiness Reporting to the Air Force Council (21 Oct 80), we would like a confirmation of the LCOM applicability and the ability of the ASD/EN Modeling and Analysis Branch to support each of the program offices, identified by attachment, in generating the sustainability chart. We don't expect the LCOM group to develop this data alone. It will have to be a combined effort by the program office and the using command. Our whole objective is to develop a reporting mechanism that utilizes the existing capability and data base to give the higher level Air Force managers visibility into the readiness of each individual weapon system while it is still in its early stages of deployment.

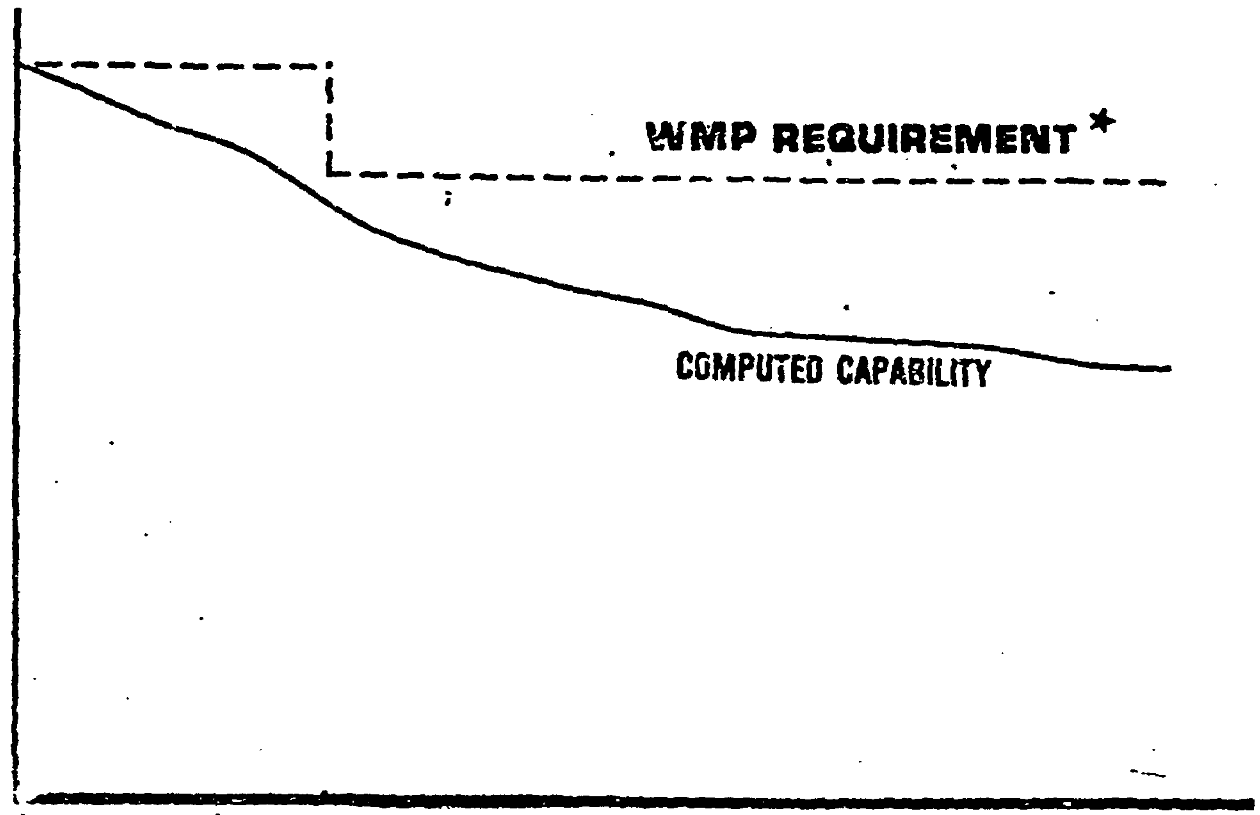
4. We would appreciate a response by 10 Oct 80. Our point of contact is Maj Merl Witt, AFSC/SDDP, AUTOVON 858-4027/6160.

FOR THE COMMANDER

[illegible] C. STEWART
Deputy Director, Acquisition Policy
DCS/Systems

2 Atch
1. System Readiness - Sustainability Chart
2. Major Aircraft Program Offices

# SYSTEM READINESS
# [SUSTAINABILITY]




* MOST STRINGENT WMP SCENARIO

Atch 1

# SYSTEM READINESS (SUSTAINABILITY)

[NEW CHART]

- OBJECTIVE
  - IDENTIFY CURRENT WMP SYSTEM REQUIREMENT
  - SHOW SYSTEM CAPABILITY OVER TIME
- LIMITED SYSTEM DATA GENERATION CAPABILITY
  - REQUIRED FOR AIRCRAFT WITH A COMBAT ROLE
  - INCLUDES SYSTEM RELIABILITY, SPARES, SE, MANPOWER
  - BASED ON LCOM – EXCLUDES POL AND MUNITIONS

MAJOR AIRCRAFT PROGRAM OFFICES REQUIRING LCOM SUPPORT

F-15

F-16

E-3A

E-4

EF-111A

KC-10

CX (when initiated)

Atch 2

Maj Thompson/ENESA/52837/14Oct80/avs

14 OCT 1980

EN

Use of Logistics Composite Model Data in Secretary of the Air Force Program Reviews (Your Ltr, 24 Sep 80)

HQ AFSC/SDD

1. We agree that the Logistics Composite Model (LCOM) appears to be the most appropriate tool for generating the type of sustainability data proposed for inclusion in Secretary of the Air Force Program Reviews (SPRs).

2. The program proposed requires extensive analysis manpower. The present manning of the Modeling and Analysis Branch cannot support requirements of the magnitude indicated by attachment 2 of your letter. The branch is fully employed with ASD studies including the Avionics Availability Study, the Advanced Tactical Attack System Mission Analysis, the development of Next Generation Trainer Models, and preparations for the C-X model development. Upon release of resources committed to the above efforts, the branch could handle three of the proposed programs. Preliminary estimates, based upon our level of effort in past programs, indicate we would need a manning increase of three people per additional project.

3. As LCOM is a versatile tool to accomplish complex analysis, we can discuss at your convenience the problems associated with establishing the capability to perform the magnitude of analysis you propose. Our point of contact is Captain Bill Radcliffe or Mr Larry Jordan, ASD/ENESA, Autovon 785-7114.

ROBERT F. LOPINA
Colonel, USAF
Deputy for Engineering

COORDINATION

| SYMBOL | | DATE |
|---|---|---|
| ENSH | CW Thompson | 14 Oct 80 |
| ENES | [illegible] | 14 Oct 80 |
| ENE | [illegible] | 14 Oct 80 |
| ENE | [illegible] | 14 Oct 80 |
| EN | [illegible] | 14 Oct 80 |

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE SYSTEMS COMMAND
ANDREWS AIR FORCE BASE, DC 20334

8 DEC 1980

REPLY TO ATTN OF: SDD

SUBJECT: Use of Logistics Composite Model (LCOM) Data for Use in Secretary of the Air Force Program Review (SPR) Sustainability Chart

TO: See Distribution List

1. HQ AFSC/SDD chaired a meeting on 18 Nov 80 at Wright-Patterson AFB OH to discuss the ramifications of using LCOM to generate the Sustainability chart data now required for aircraft programs briefing the SPR. (Atch 2 is the list of attendees.) The primary purpose was to identify issues associated with using LCOM to generate this chart and which organization could support the various program offices. (See Atch 3 for draft Sustainability chart and instructions.)

2. Request that by 16 January 1980 all addressees review the positions presented here and confirm their agreement related to their program/ responsibilities listed below. The requirement to use the Sustainability chart is being staffed at SAF now and we anticipate a decision within a month. The Sustainability chart will be presented at the first opportunity to obtain meaningful LCOM data after this decision.

3. In discussing the application of LCOM to the F-16, F-15, and EF-111A requirements, it was generally agreed that TAC/LGY could best support the F-15 SPO, that the TAC LCOM operating location in the F-16 SPO could best support the F-16 SPO, and that ASD/EN could best support the EF-111A SPO. All three of these efforts would require two men working approximately 6 months to update the data base and generate the first chart for the SPR. A MOA would be required between the F-15 and F-16 SPOs and TAC. The generation of the sustainability data will impact ongoing work and may require shifting of priorities since no additional manpower or funds are available in conjunction with this requirement.

4. The application to the other major aircraft would be:

a. E-3A: The E-3A LCOM would take considerably more effort than the F-16, F-15, or EF-111A models. Also, the LCOM wartime scenario is outdated and the impacts of the NATO E-3A fleet are undefined. Therefore, the requirement for the Sustainability chart shall be deferred until an LCOM is developed for the US/NATO standard configured aircraft.

b. A-10: None of the organizations represented had a current capability for the A-10. USAFE is currently conducting an A-10 surge sortie analysis which may very easily support the Sustainability chart requirement. HQ AFSC/ SDD will follow up on this with USAFE and advise the SPO accordingly.

c. KC-10: The KC-10 LCOM is currently being developed by AFTEC and the initial effort will be complete in April 1981. Any effort after April should include the sustainability requirement for the SPR. Since the SPO has no in-house LCOM capability, an MOA between the SPO and AFTEC covering the Sustainability chart effort will be necessary.

d. C-X: ASD/EN is currently developing the LCOM for C-X. Since the sustainability briefing requirement is known at the beginning of this development, there should be no significant impact on man-years of effort to develop and maintain the Sustainability chart.

5. LCOM appears to be the only practical simulation that could provide the sustainability data, although there are problem areas of data base updating, scenario coordination, and spares use assumptions. In addition, there will be a need to maintain a data base and produce the sustainability analysis at least once and perhaps twice a year. Use of the LCOM as a data source for the SPR will mean that it will be an continuing management tool and that additional resources will have to be programed for the duration of the acquisition cycle. Specific points and positions expressed in the meeting are contained in Atch 4. Your comments or suggestions for dealing with some of the problems presented would be appreciated.

6. We anticipate approval of the new SPR format by early January 1981, at which time we will issue the direction needed to conduct this effort. Point of contact for this effort at HQ AFSC is Maj Merl Witt (AFSC/SDDP), AUTOVON 858-6160.

FOR THE COMMANDER

PERRY C. STEWART
Deputy Director, Acquisition Policy
DCS/Systems

4 Atch
1. Distribution List
2. Attendance List
3. Draft Sustainability Chart and Instructions
4. Problem Areas/Considerations in Applying LCOM in Generating an SPR Sustainability Chart

## DISTRIBUTION LIST

Program Offices:

HQ ASD/YPL/YPP WP AFB OH 45433
HQ ASD/TAF WP AFB OH 45433
HQ ESD/YWL Hanscom AFB MA 01730
HQ ASD/TAX WP AFB OH 45433
HQ ASD/AFH WP AFB OH 45433
HQ ASD/RWJ WP AFB OH 45433
AFALD/YT WP AFB OH 45433

Meeting Attendees:

Jimmy D. Bias, OC-ALC/MMEAL Tinker AFB OK 73145
Lt Col Ronald Clarke, HQ TAC/LGYT Langley AFB VA 23665
Capt Del Atkinson, HQ ASD/RWEE WP AFB OH 45433
Maj Clyde Thompson, HQ ASD/ENE WP AFB OH 45433
J. H. Nickerson, HQ ASD/RWJT EF-111A SPO WP AFB OH 45433
Frank Evans, HQ ASD/SWL WP AFB OH 45433
Capt Royce Kennedy, HQ AFTEC/LG Kirtland AFB NM 87117
Capt Guy A. Chabot, HQ ESD/YWX Hanscom AFB MA 07130
Capt R. K. Rasmussen, AFALD/YT WP AFB OH 45433
Maj Dave Miller, AFMSMET WP AFB OH 45433
2Lt Michael A. Coppelano, HQ ASD/TAF WP AFB OH 45433

Others:

HQ USAF/MPME Wash DC 20330
HQ USAFE/MOM (Info)
HQ PACAF/XPM Hickam AFB HI 96853 (Info)

Atch 1

ATTENDANCE LIST

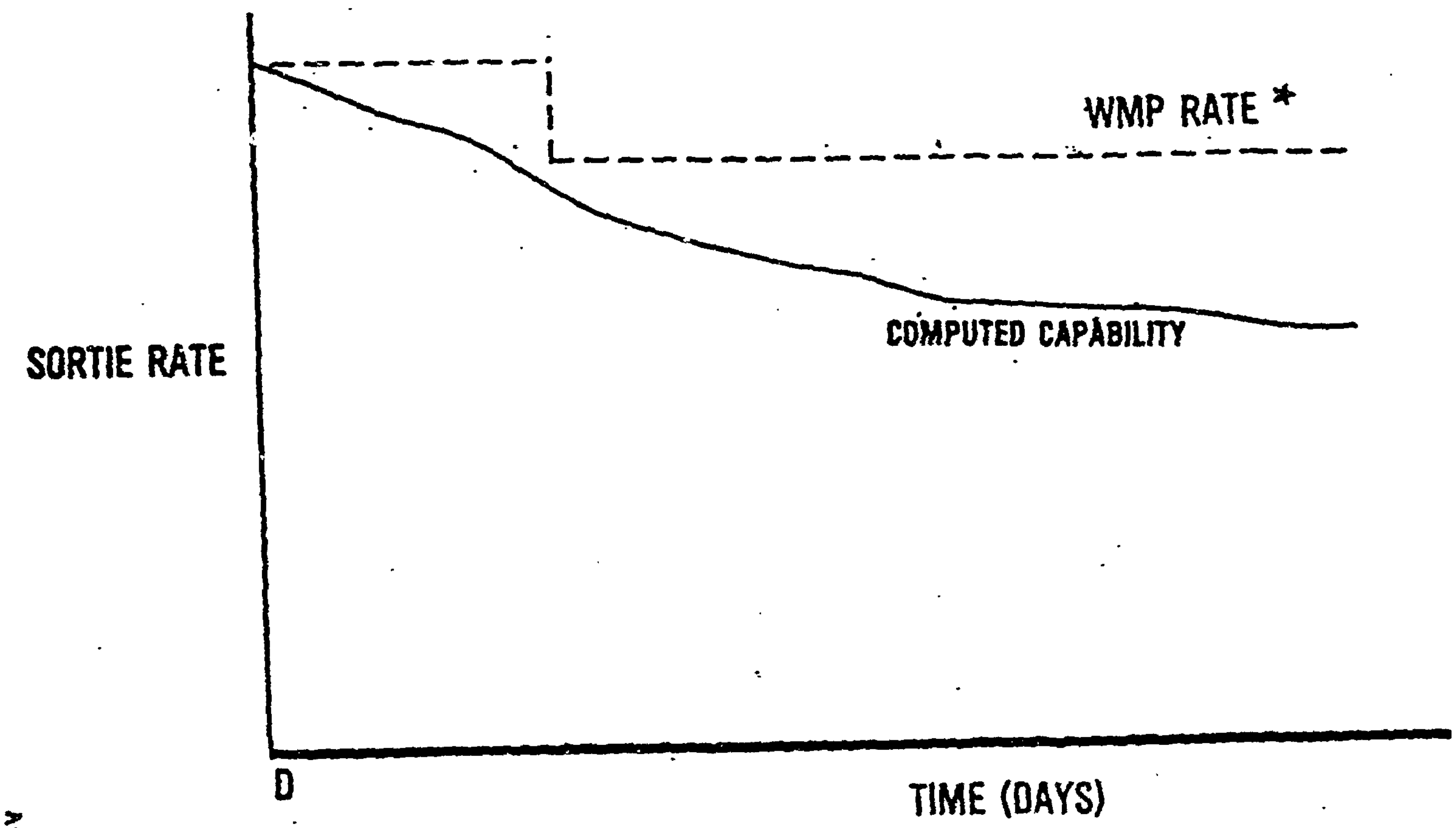
LCOM SPR Application Meeting - 18 November 1980

| NAME | OFFICE | TELEPHONE NUMBER |
|---|---|---|
| Maj Merlyn Witt | HQ AFSC/SDD | AUTOVON 858-4027 |
| Jimmy D. Bias | OC-ALC/MMEAL | AUTOVON 735-6008 |
| Lt Col Ronald Clarke | HQ TAC/LGYT | AUTOVON 432-3427 |
| Capt Bob Yunag | ASD/YP<br>4400 MES/OLAA (TAC) | AUTOVON 785-2711 |
| Kenneth Bawman | ASD/ADD | AUTOVON 785-6633 |
| Jeffrey Melaragno | ASD/ENESA | AUTOVON 785-7114 |
| Capt Jim Lowell | HQ AFTEC | 255-0346 |
| Gene Gross | ASD/AFEE | 255-2861 |
| Capt Del Atkinson | ASD/RWEE | AUTOVON 785-5816 |
| Maj Clyde Thompson | ASD/ENESA | AUTOVON 785-2837 |
| 1Lt Michael R. Clark | AFALD/XRSA | AUTOVON 785-5700 |
| Jitti Nickerson | ASD/RWJL EF111A SPO | AUTOVON 785-6424 |
| 2Lt Michael S. Coppelano | ASD/TAF | 255-3266 |
| Ben Wince | ASD/AWL | AUTOVON 785-3619 |
| Frank Evans | ASD/AWL | AUTOVON 785-4229 |
| Mary Case | ASD/ENESA | 255-7114 |
| Richard Cronk | ASD/ENESA | AUTOVON 785-7114 |
| 2Lt Eugene R. Richards, Jr | ASD/ENESA | AUTOVON 785-7114 |
| Capt John Koch | ASD/ENS-A/C | AUTOVON 785-6582 |
| Capt Royce Kennedy | HQ AFTEC/LG | AUTOVON 244-0346 |
| Capt Guy A Chabot | HQ ESD/YWXP | AUTOVON 478-10001<br>MITRE 2208 |
| W. Shaughnessy | HQ ESD/YWXP | AUTOVON 478-1001<br>MITRE 2209 |
| Capt R. K. Rasmussen | AFALD/YT | 785-5624 |
| Margaret Joering | AFALD/YT | AUTOVON 785-5015 |
| Capt Bill Radcliffe | ASD/ENESA | AUTOVON 785-7114 |
| Maj Dave Miller | AFMSMET | AUTOVON 787-6393 |

Atch 2

DRAFT

# SYSTEM READINESS
# [SUSTAINABILITY]




★ MOST STRINGENT WARTIME SCENARIO

Atch 3

TITLE: SYSTEM READINESS (SUSTAINABILITY)

REQUIREMENT: Mandatory for all aircraft systems with a sustained wartime role.

PURPOSE: To show the capability to sustain wartime operators.

INSTRUCTIONS:

1. The requirement (dashed line) is based on the War and Mobilization Plan (WMP). The chart shows sortie rate, (tactical aircraft) or flying hours (airlift and strategic) on the vertical axis and time in days on the horizontal axis. The time period should be consistent with that in the current Consolidated Guidance. For deployed systems, the computed capability will reflect current resources actually available to support operations. For systems not yet deployed, the computed capability should be calculated for IOC and be the result of quantitative analysis based on test data, if available.

2. This chart will be shown starting in the full scale development phase as soon as sufficient reliability, spares, manpower, support equipment utilization data or projections are available to allow a realistic Logistics Composite Model (LCOM) computation.

3. The computed capability is based on the Logistics Composite Model Simulation. ASD/EN, AFTEC or the using command, depending on the stage of the program, may be the lead in performing this analysis with support from the program office. The responsible group will be identified in a Memorandum of Agreement with the program office *. This chart must be coordinated with the using and supporting commands. HQ AF/XOOX produces the War Mobilization Plan and is the source of WMP data and information. Use the current WMP available from the respective product divisions planning organization.

4. If the system capability is less than the requirement, an explantory chart must be prepared which identifies, as a minimum, the limiting element(s) (manpower, spares, support equipment utilization, or system reliability). Any factors not included in the LCOM which might adversely affect sustainability should be identified.

* HQ AFSC/SDDP will help establish agreements between the SPO and the appropriate LCOM group. Tentative arrangements are:

F-16: TAC/XPM operating location at WP-AFB.

F-15: TAC/LGY

EF-111 A: ASD/EN

KC-10: AFTEC

E-3: TBD (LCOM will be completely updated to reflect the NATO configuration. The group doing the update will also generate the sustainability data.)

C-X: ASD/EN

The initial presentation of this chart will not be required until the LCOM data base is updated by the supporting LCOM group (This may require approximately six months).

## PROBLEM AREAS/CONSIDERATIONS IN APPLYING LCOM IN GENERATING AN SPR SUSTAINABILITY CHART

### EF-111A

ASD/EN proposes a 6-month effort involving two analysts to generate the EF-111A SPR Sustainability chart using an EF-111A LCOM. This model and detailed scenario information are available from HQ AFTEC. The model would be updated in cooperation with HQ TAC/XPM efforts.

Of primary importance is the cooperation and support of the EF-111A SPO Their funds would be required for TDY purposes. The EF-111A DPML would have to be intimately involved in the development of the combat scenario. Through the DPML, AFLC, ALD, and the system manager would be involved in the development of the sustainability chart. AFTEC and TAC would continue their involvement throughout the effort. The Air Staff would also have to coordinate on scenario development and LCOM analysis results.

### C-X PROGRAM

This is an excellent opportunity to apply a joint modeling group to development of an LCOM to measure supportability (also produce sustainability chart). With the proper emphasis from all involved parties, this tool could be very effective in tradeoffs, capabilities, and other analyses.

Suggested group should contain one full-time logistician, one full-time using command representative, one SPO representative, and one modeler from the LCOM shop. After initially building the model, the support can be reduced to two people full time to keep the model up-to-date.

The model can be developed to perform supportability analyses in addition to manpower requirements, and can be done quickly with the model. The most difficult task is the scenario development and scenario coordination. There is no established procedure for coordinating a usage scenario. It is currently coordinated by the modeler who determines should coordinate on it.

### E-3A

The tasking for the System Readiness Sustainability chart for the E-3A program shall be deferred until an LCOM is developed for the US/NATO standard-configured aircraft system. The rationale is that the LCOM wartime scenario for E-3A core-configured aircraft is outdated and impacts from US support of the NATO E-3A fleet are undefined. Also an update of the present E-3A LCOM would require approximately six people (TAC and AFLC) to provide updated scenarios. Time required would be 12-18 months.

Any MOA or LOA should be negotiated between MAJCOMs. The inputs for a briefing to the Secretary should be coordinated MAJCOM positions on a particular subject.

Atch 4

F-16

HQ TAC/XPM (LCOM) has an F-16 sustained wartime data base which is updated on an annual basis. Additionally, a surge data base exists; although, it is over a year old. While a surge excursion was performed sometime ago, there may not be a viable, approved surge scenario available. The Sustainability SPR chart would require two people working 6 months and could be done by the F-16 TAC operating location, which was placed within the F-16 SPO to provide support for projects similar to this SPR chart. The data base exists to support this requirement, and it can be made available to an AF agency which can support the requirement.

There is a potential problem, however, is that TAC feels the requirement for the operating location diminishing, and it could be phased out within 1½ years. XPM may not have the resources to support an SPR requirement, unless high level directives establish the priority.

F-15

Since LCOM is a relatively resource intense analysis process, with a scarcity of trained resources, a position was taken regarding the most logical manner to get the SPR studies initiated. This position did not consider current tasking of the organizations concerned and recognized coordination required. To produce a F-15 SPR chart would require two persons working near full time approximately 6 months. This would consume approximately one-half of the TAC LG LCOM capability.

A considerable effort in performing an LCOM capability assessment is associated with the development and coordination of an LCOM scenario which contains the operational factors and the major assumptions. Also the collection and processing of information related to the current spares posture and support equipment availability is a major workload.

An MOA between the SPO and organization doing the study and perhaps the SM is highly desirable if not an absolute necessity.

KC-10

AFTEC is presently developing an LCOM analysis for the KC-10. The initial "first-cut" on this analysis will be completed in March to April 1981. After review of this "first-cut" LCOM analysis, SAC, AFTEC, and the KC-10 Joint Program Office will determine if alternate scenarios are appropriate for future LCOM consideration.

An issue of some concern is that the first scenario developed for the KC-10 does not fully evaluate the advertised utilization rates. The commercial aspects of the KC-10 program especially in the supply support area may suggest that future LCOM efforts are not required on a recurring basis. Future LCOM analysis after the AFTEC effort will, therefore, be a subject of future consideration in conversations between the JPO and SAC.

AFTEC does not have a SAC, MAC, TAC, and AFLC approved scenario. SAC and AFLC (the JPO) have provided AFTEC with an initial first-cut scenario. Future LCOM efforts must include/consider an "approved" scenario. This effort to come up with an approved scenario will possible not begin until after the March 1981 review of AFTEC's first-cut.

## GENERAL

A quantitative "systems' approach to assessing the sustainability of aircraft systems is desirable. LCOM is a sensible alternative; however, there maybe severe limitations in terms of resources (computer capability, people) throughout the existing LCOM community. The major problem will be the "scenario" development, including the data base and assumptions. Several organizations must provide inputs. A valid assessment can be made only if all applicable organizations provide inputs, concur on assumptions, etc.

The LCOM is a "unit level" assessment. It does not provide a fleet level view. It also does not address munitions. The Air Force should seriously consider contracting for a new model which gives upper level management a "macro" view of the total fleet capability.

3

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